Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

AUGUST, 1958

TECHNOLOGY DEPT.

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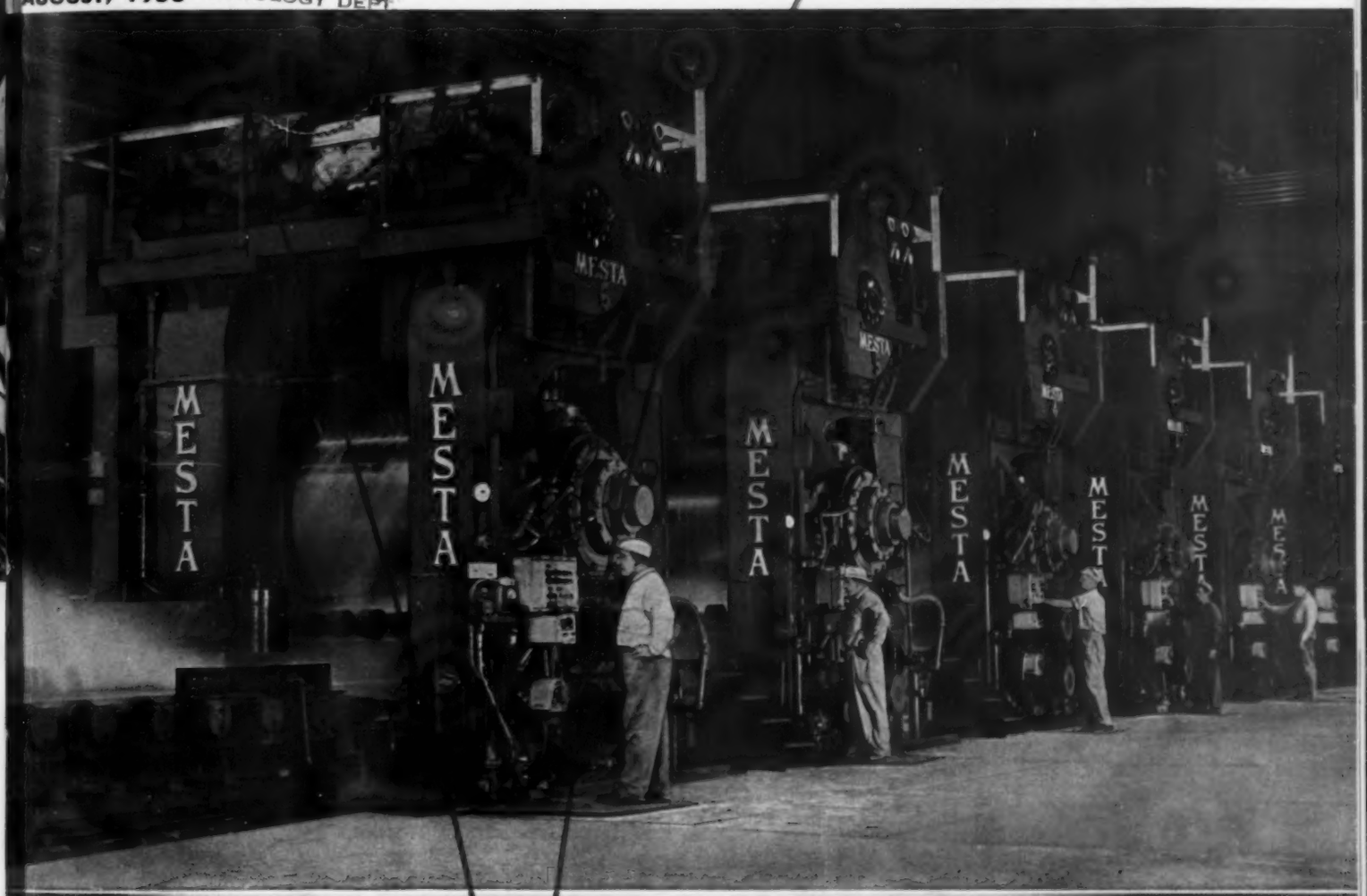

SIX FINISHING STANDS OF THE MESTA 60" FOUR-HIGH HOT STRIP MILL OPERATING AT McLOUTH STEEL CORPORATION, TRENTON, MICHIGAN

HOT STRIP MILLS

Designed and Built by MESTA

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA, U.S.A.

MESTA

THERE IS NONE BETTER

This welded magnet can really make sense to you

The *coil* is welded into a capsule, removable and replaceable in the field

The outer pole shoe is welded to the body

And it all adds up to more copper, more lift, more life, more "no-trouble" periods.

Now available to you in a *better* welded design is the Cutler-Hammer Supermagnet . . . the magnet that has been "super" since it started. We say this is better because here welding makes sense. Welding is used to seal the coil into a compact, homogeneous, monolithic mass that is moisture proof and can be removed from the body on the job for repairs without trouble.

Welding is used to unite the cast dynamo steel body and the alloy steel outer pole shoe into a rugged, wear-resistant unit. On the other hand, this unit retains the uniformity of magnetic flux density between the inner and outer pole shoes that means more lifting power, a bigger "bite."

The coil shield has an improved and heavier cross section to better protect the coil. The inner pole shoe—which of all magnet parts gets most wear—is *NOT* welded but held in place by countersunk through bolts, so it can be easily removed and replaced.

You'll find other advantages too—the design of the lugs, the design of the cast steel chain yoke, the design of the terminal box: these are some of the features that make the "Supermagnet" super. Ask for new magnet book THE BIG LIFT. Shows the complete C-H line welded, bolted and special magnets. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wisconsin.

CUTLER-HAMMER
SUPERMAGNETS
C-H

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., Pittsburgh, Pa. Second class mail privileges authorized at Pittsburgh, Pennsylvania, January 25, 1924.

AETNA-STANDARD

ENGINEERING COMPANY · PITTSBURGH PA · U · S · A

DATE	PATENTS	NUMBERS
MADE [illegible] 1928	[illegible]	MAKERS [illegible]
STARTED [illegible] 10 1952		USERS [illegible]

Seal of Approval

for the KAUFMAN SINGLE SHEET CLASSIFIER

made by AETNA-STANDARD

MANY FEATURES AVAILABLE

ONLY

IN THIS PATENTED CLASSIFIER

This name plate represents progressive engineering and patented features . . . a mark of leadership as exemplified by quality, reliability and accuracy.

The patented Aetna-Standard Sheet Classifier sorts and piles sheets at high speeds automatically, selecting by gauge, surface and pinholes.

Controls, operated electronically, instantly spot imperfections and classify the sheets. Magnetic "eyes" also hold down the sheets and keep them in a straight line for fast, steady production.

Most classifiers the world over carry this name plate, a symbol of Aetna's leadership in designing and building of equipment. The Classifier is used on many types of processing lines for the classification of electrolytic tin plate, black plate, cold reduced sheets and aluminum sheet products.

AETNA • STANDARD

THE AETNA-STANDARD ENGINEERING COMPANY

GENERAL OFFICES: PITTSBURGH, PA. PLANTS: ELLWOOD CITY, PA., WARREN, OHIO

CONTINUOUS GALVANIZING LINES • CONTINUOUS ELECTROLYTIC TINNING LINES • SIDE TRIMMING AND SHEAR LINES AND OTHER FINISHING EQUIPMENT • CONTINUOUS BUTT WELD PIPE MILLS • SEAMLESS TUBE MILLS • DRAWBENCHES AND OTHER COLD DRAW EQUIPMENT • ROLLS AND CASTINGS • EXTRUDERS, MILLS, PRESSES FOR RUBBER AND PLASTIC

How perfectly simple —this Fast's Coupling with purely mechanical flexibility!

1. A hub is keyed on each shaft. Hubs are splined at maximum distance from shaft ends.
2. Floating sleeves surround hubs. Sleeves are splined to engage hub splines.
3. Sleeves compensate for shaft misalignment by assuming neutral position between two hubs.
4. Because of distance from shaft end, any misalignment between splines is mere fraction of same misalignment between shafts.
5. Sleeves carried on bearing rings, located on transverse center line of hub spline faces (the load-carrying surfaces) . . . no crank action, no vibration.
6. Lubricant is centrifugally forced into spaces between engaged splines, forming a film.

For 35 years the most positive, dependable means of coupling machines to their power source . . . Fast's Couplings have no parts subject to repeated bending, tension or compression. Because there is no metal-to-metal contact, *there is no wear*—in fact, many Fast's Couplings in use for over 30 years show no signs of wear when disassembled! No leather, plastic or rubber oil seals. Lubricant film distributes pressure over a considerable area, diminishing localized stress at pressure points on the load-carrying teeth. Perfectly simple? Yes . . . and foolproof!

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THE ORIGINAL **FAST'S Couplings**

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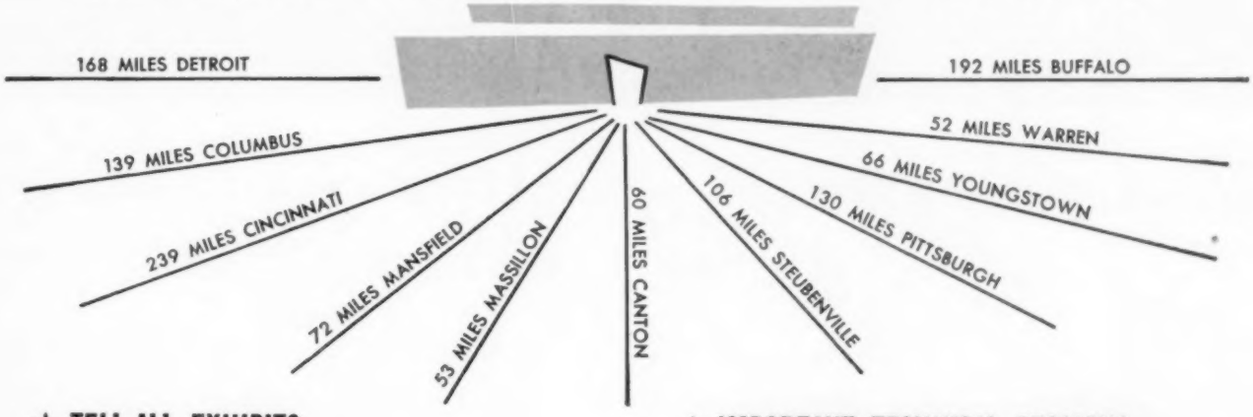
METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD.
This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Industrial Gas Cleaning Apparatus, Aeromaster Fans.
Engineered Products Sold with Service.

AN EASY TRIP FROM MOST LOCATIONS—GO SEE!

THE 1956 IRON & STEEL EXPOSITION

CLEVELAND PUBLIC AUDITORIUM SEPT. 25—28!



★ **TELL-ALL EXHIBITS**

More than 200 companies that supply materials, equipment and services to the Steel Producing Industry will reveal their latest advances in eye-catching, informative displays and demonstrations.

★ **IMPORTANT TECHNICAL SESSIONS**

Four full days of intensive technical sessions offer a liberal education in "What's New" in steel plant operation, methods, planning, maintenance and many other pertinent subjects.

IRON AND STEEL EXPOSITION

The Industry's Most Specific Show!

***For additional information,* write**

Association of Iron & Steel Engineers, 1010 Empire Bldg., Pittsburgh 22, Pa.

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DESIGNERS AND BUILDERS OF:

- STEEL MILL MACHINERY
- HYDRAULIC PRESSES *(Metalworking and Extrusion)*
- CRUSHING MACHINERY
- SPECIAL MACHINERY
- STEEL CASTINGS
- Weldments "CAST-WELD" Design
- ROLLS: Steel, Alloy Iron, Alloy Steel

If your new mill is still in the idea stage . . . If you have been thinking about modifying your present mill . . . If you have a production problem that can be solved by extensive experience and engineering ability . . .

Call in a Birdsboro representative to discuss your plans. In addition to his own knowledge, he has the entire Birdsboro staff on call and will gladly start the machinery that will put them to work on your job. In nearly every case, there are better ways to do it . . . and Birdsboro either already knows them or will help to find them for you.

MM-51-56

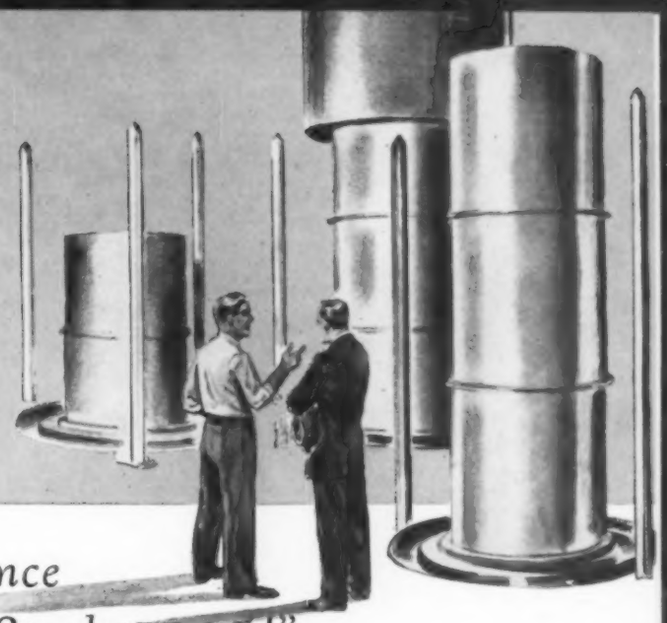
BIRDSBORO

BIRDSBORO STEEL FOUNDRY & MACHINE CO., Main Offices in Birdsboro, Pa. District Office: Pittsburgh, Pa.

New York Office: **Engineering Supervision Co.,** *120 West 42nd Street, New York 36, N.Y.*

THIRD IN THE SERIES

Customer's Report



"Every charge is special—since we went Single Stack 100%!"

In the course of a conversation with a large steelmaker, he wrote this advertisement for us when he said — "I like this single stack annealing system. It enables us to give every charge preferential treatment. When we had the old four stacks, we used a couple of these single stack furnaces for those special orders that required higher quality anneal, or had to be delivered in a rush. Now, with all single stacks, *every order is a special order with us*, and with the return of stronger competition, I think it will pay off big."

It's been proven time and time again. The single stack will do a better job, faster. This means closer annealing control, important in modern metals — and better customer service, fewer dollars tied up in process inventory. The advantage is all with the single stack. And it's important to remember, too, Lee Wilson developed and designed more than 95% of the single stack equipment in operation today.

Only Lee Wilson Furnaces Give You All These Advantages

1. GREATER FLEXIBILITY
2. MORE UNIFORM HEAT APPLICATION
3. IMPROVED CUSTOMER SERVICE
4. HIGHER PRODUCTION
5. BETTER LOAD FACTOR
6. MINIMUM PROCESS INVENTORY
7. REDUCED LABOR COST
8. BETTER OPERATING CONDITIONS
9. LOWER MAINTENANCE COST
10. REDUCED INSTALLATION COSTS

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SINGLE-STACK RADIANT TUBE ANNEALING FURNACES

MAKE THE BEST METALS BETTER

* ORIGINATORS AND LEADING PRODUCERS OF SINGLE-STACK RADIANT TUBE FURNACES

10045

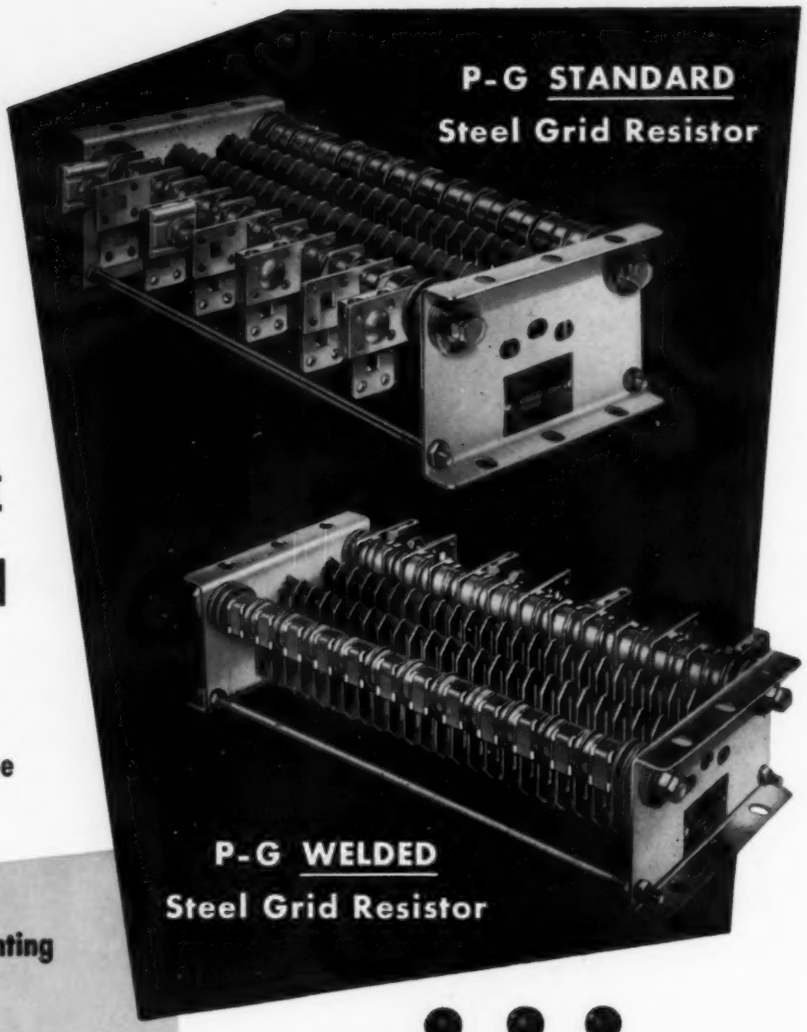
The trend is to single stack. One of the nation's largest annealing departments recently put into operation 24 Lee Wilson Single Stack Furnaces and 72 bases.

P-G the ORIGINAL

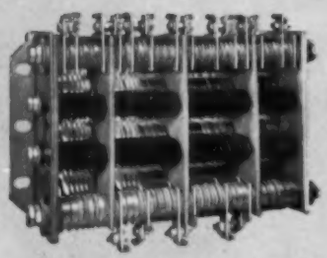
Steel Grid Resistor

plays an essential part in the production of steel

Built for severe service conditions
Protects vital electrical equipment
Constant "trouble free" performance
Quick adjustments easily made

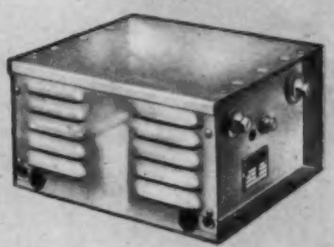


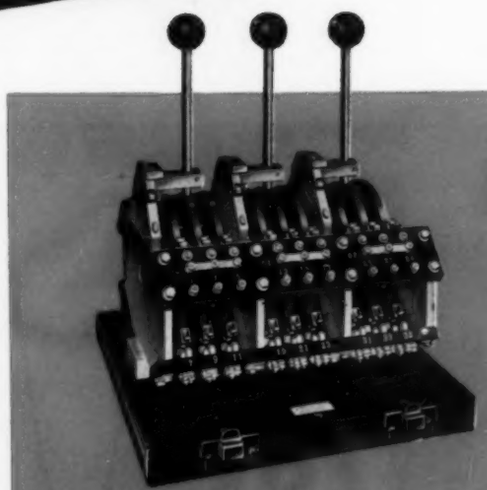
P-G Resistors for Internal Mounting in Face Plate Controllers



Standard Units for 2 to 25 H. P. Motors. Also supplied for external mounting.

P-G Resistors for
SAFETY LIMIT STOPS
Available in standard units for any size motor.





P-G Type MD Master Switch
for general application in Mill Service

Save valuable mounting space . . . One to four switches in a single enclosure . . . Overall length less than 22" on four-unit Switch.

P-G

Send for Bulletins

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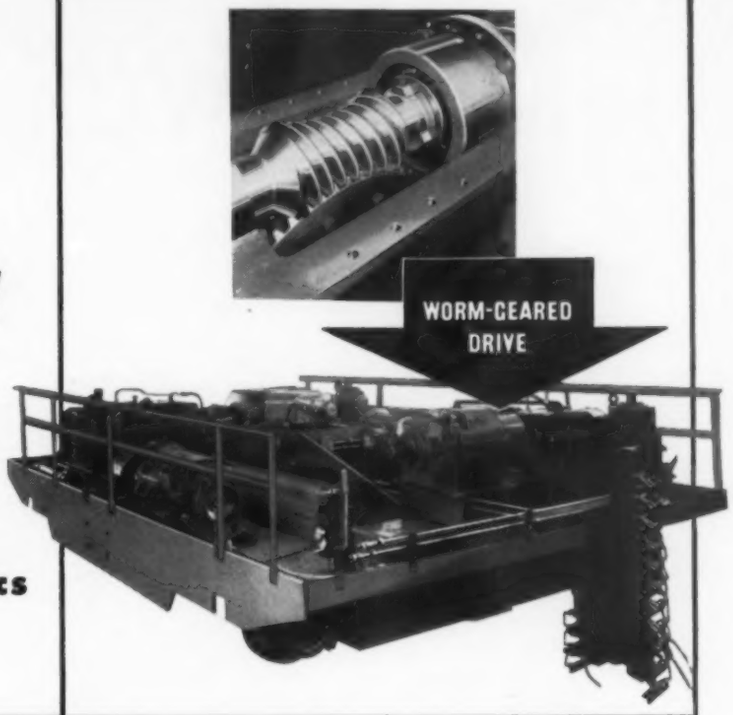
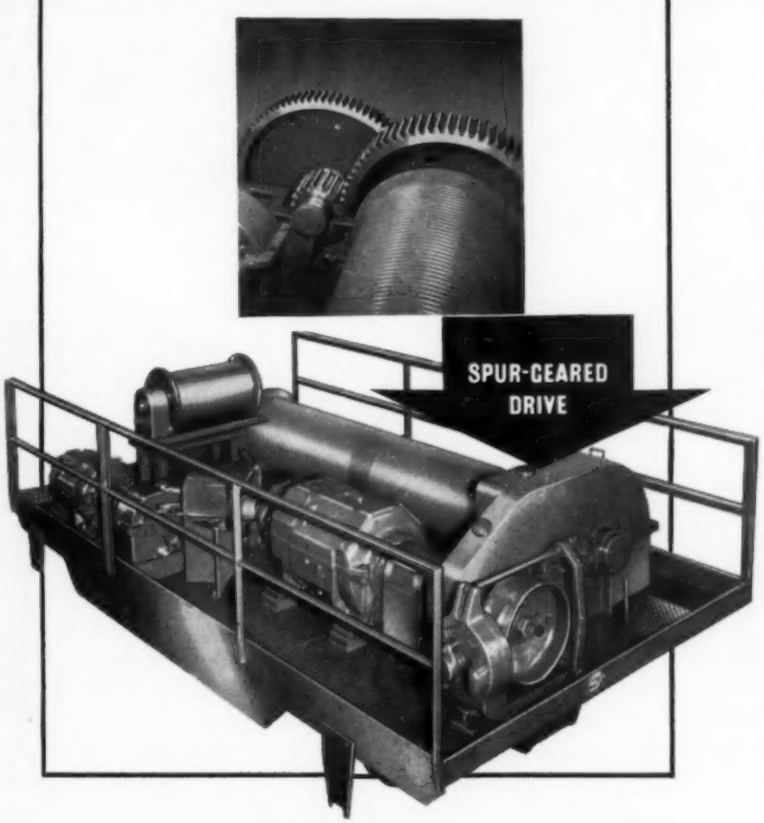
CHOOSE THE TROLLEY

YOU LIKE BEST

SHAW-BOX

Builds both to A.I.S.E. Specs





You want trolleys of the type your experience has proved are best for your particular requirements. The two types of trolleys and their gearing shown here illustrate how A.I.S.E. specifications are interpreted by Shaw-Box in satisfying the needs of two different mill applications.

Whether you prefer worm or spur gearing on your trolleys, turn to Shaw-Box and be sure of the finest in precision manufacture. Our long experience in designing, engineering and building load handling equipment exclusively assure you of continuously dependable performance, regardless of service conditions.

Over the years, we have produced many 5 to 200-ton cranes of various types to A.I.S.E. specifications and to the specifications of individual mills. Their work records prove the economic value of mechanical and operational features conceived and introduced by Shaw-Box. So if your plans include a crane to handle plate or slabs, a soaking pit carriage or a giant ladle crane, we invite your inquiry.

You are cordially invited to visit our Booth No. 263—AISE Show, Cleveland Auditorium, September 25-28.

"Shaw-Box"® CRANES

MAXWELL MANNING & MOORE INC. M&M TRADE MARK

MANNING, MAXWELL & MOORE, INC.

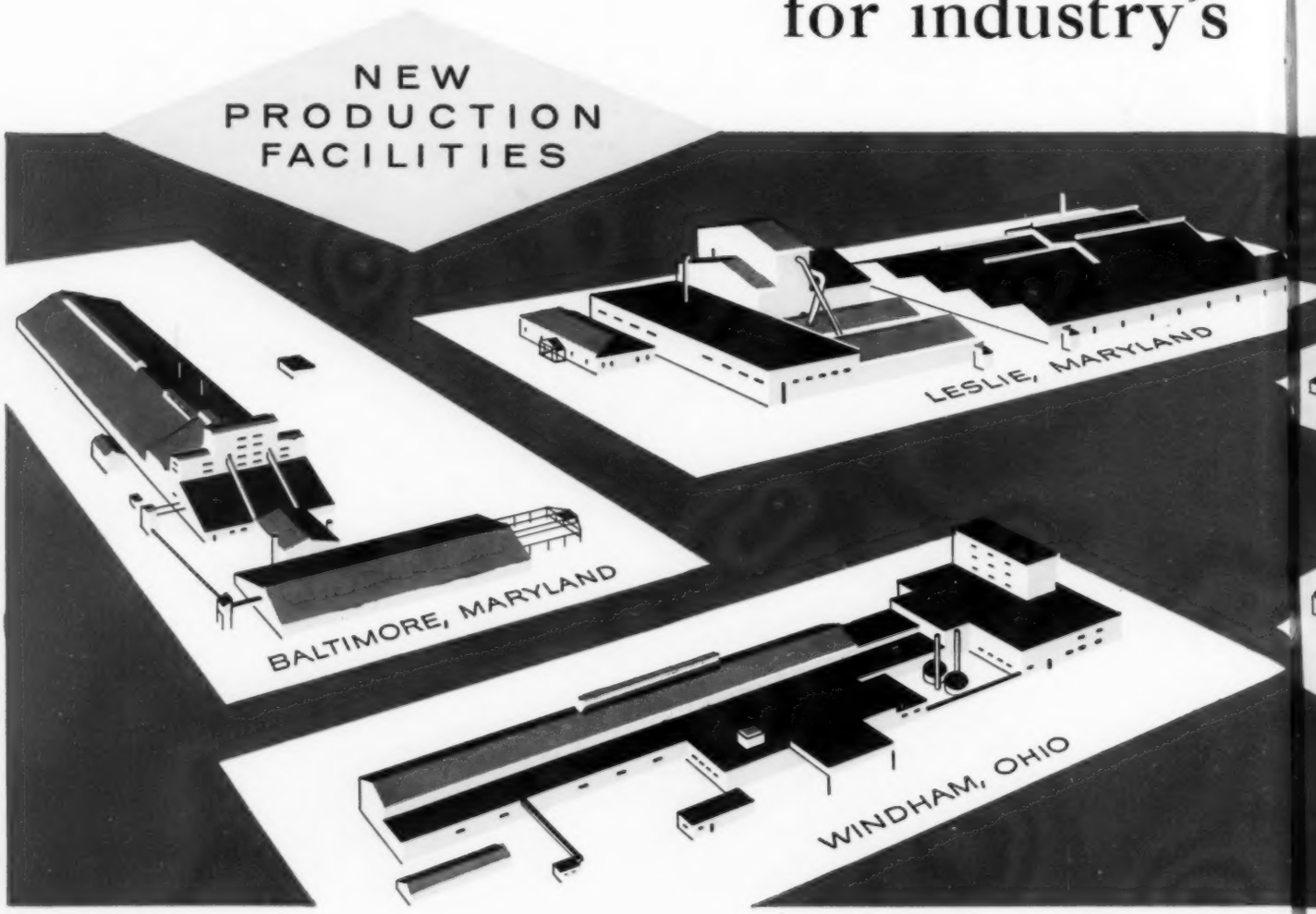
SHAW-BOX CRANE & HOIST DIVISION, MUSKEGON, MICHIGAN

Builders of "SHAW-BOX" and 'LOAD LIFTER' Cranes, 'BUDGIT' and 'LOAD LIFTER' Hoists and other lifting specialties. Makers of 'ASHCROFT' Gauges, 'HANCOCK' Valves, 'CONSOLIDATED' Safety and Relief Valves, 'AMERICAN' and 'AMERICAN-MICROSEN' Industrial Instruments, and Aircraft Products.

56K-2

A-665

Harbison-Walker BUILDS for industry's

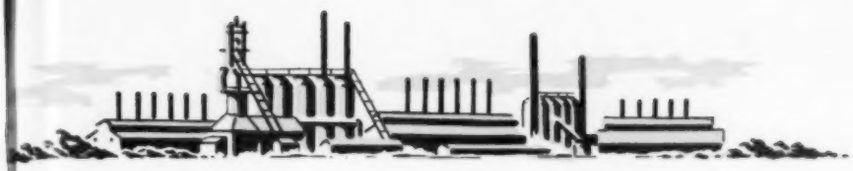


RAPID GROWTH and evolutionary changes in substantially all industrial processes necessitate similar progress in the production of refractories. In order to meet industry's increasing demands and in anticipation of even greater and more exacting future requirements, Harbison-Walker has conducted a continuous program of expansion and modernization. Consistent with this policy, a number of new plants have been built, some of which are here illustrated. Other new plants are under construction at Ludington, Michigan and Hammond, Indiana, the former for the production of dead-burned magnesia of unusually high purity, and the latter for the manufacture of basic brick and other basic refractories. Both will be provided with docks for water shipment. These two new additions provide Harbison-Walker with a total of 36 plants in the United States, Canada, Peru and Mexico. The Company operates scores of mines and quarries located in these areas.

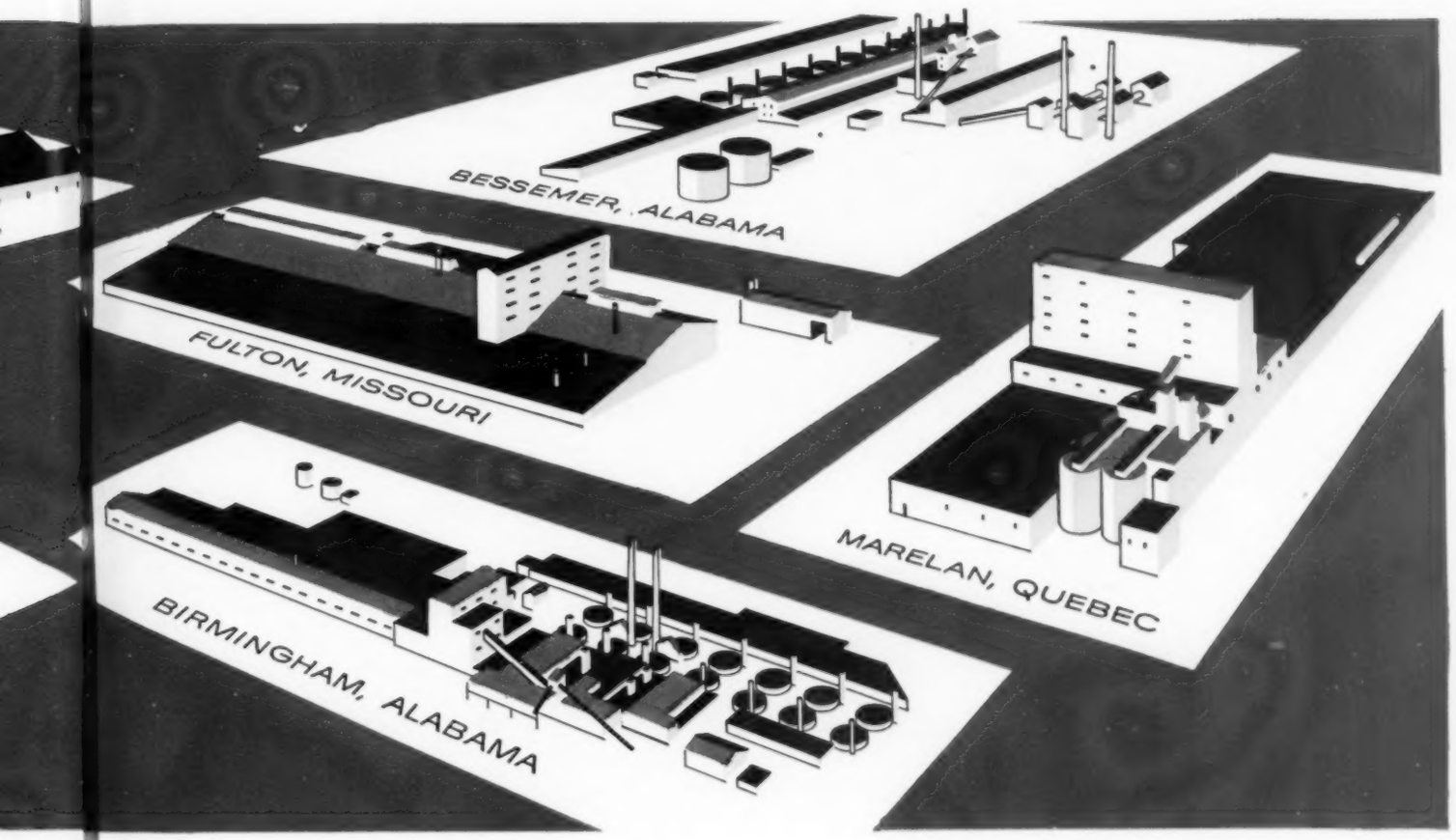
In addition, the production capacities of other plants have been materially increased with the benefit of the most modern facilities. These widely distributed plants are located at Warm Springs, California; Athens, Texas; East Chicago, Indiana; Olive Hill, Kentucky; Portsmouth, Ohio; and Clearfield, Pennsylvania. Further expansion will follow as required.

Coupled with this large expansion is an accelerated research program. A new greatly enlarged central research laboratory will be built in Pittsburgh and the present laboratory then will be converted entirely to Quality Control. Among the main research objectives is the development of new types and classes of refractories needed for new processes and for withstanding more severe service conditions. Another important research accomplishment is the continual enhancement of properties of conventional refractories. Laboratory research is closely co-ordinated with extensive studies of the performance of various refractories in the many kinds of metallurgical and other industrial furnaces.

Harbison-Walker has consistently kept pace with



future refractories needs



industry by the development and adoption of new and improved manufacturing methods. The most modern and precise production processes are used. The present Quality Control Program exceeds anything previously employed in the refractories industry.

These Harbison-Walker progressive accomplishments contribute greatly to better refractory practice for industry. To the producers of iron and steel, aluminum, copper and other non-ferrous metals, cement, glass, chemicals and steam power, better refractories mean longer furnace life, less maintenance and reduced operating costs.

HARBISON-WALKER SERVES ALL INDUSTRIES WITH ALL TYPES AND CLASSES OF REFRACTORIES

ALUMINA-SILICA BRICK—Super-duty, high duty and all other classes of fireclay brick.

HIGH-ALUMINA BRICK—All classes 50% to 99% Al_2O_3 inclusive.

SILICA BRICK—Super-duty and conventional.

BASIC BRICK—Metalkase, periclase, magnesite, chrome, forsterite, chrome-magnesite and magnesite-chrome.

INSULATING REFRACTORIES • PLASTIC AND CASTABLE REFRACTORIES • HIGH TEMPERATURE BONDING MORTARS • REFRACTORY RAMMING MIXTURES • GRAIN AND LUMP SIZE REFRACTORY MATERIALS

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The World's Most Complete Refractories Service

HARBISON-WALKER REFRACTORIES CO.

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GENERAL OFFICES: PITTSBURGH 22, PENNSYLVANIA

OFFICES AND WAREHOUSES IN PRINCIPAL CITIES

Bailey Recorder for receiving pneumatic and electric signals.

Measured Variables

- % combustibles
- combustion
- conductivity
- density
- differential
- draft
- flow
- liquid level
- % oxygen
- pH
- position
- pressure
- ratio
- smoke density
- specific gravity
- speed
- temperature
- vacuum

Pick any four, plug in, and record

Here is a receiver recorder, custom-built *by you* to meet your needs, no matter how changeable, how complex. On a single chart you can record any four measured variables—and interchangeable receivers permit new combinations almost at will.

Individual plug-in pneumatic or electronic receivers—and corresponding integrators—are interchangeable in the four identical frame slots. You can select any combination; even including two receivers and their two integrators.

Think what this can mean to you! Parts inventories are minimized; re-use of components keeps instrumentation costs economically low when cycle changes are frequent—and you can even tie in with your existing transmitters.

Ask for Product Specification E12-5.

P89-1

ONLY BAILEY OFFERS ALL THESE ADVANTAGES IN A SINGLE RECORDER

- Pre-calibrated plug-in receiver units
- Up to four pneumatic or electronic receivers —or two receivers and two integrators
- Any four variables on one chart—easily read and interpreted
- A full year's ink supply at one loading
- Faster ordering—from stock
- Minimum inventory of parts
- Minimum instrument investment for process cycle expansion or alteration

BAILEY METER COMPANY

1047 IVANHOE ROAD

CLEVELAND 10, OHIO

Controls for Power and Process

BAILEY METERS

Controls for

TEMPERATURE
PRESSURE
GAS ANALYSIS
FLOW · LEVEL
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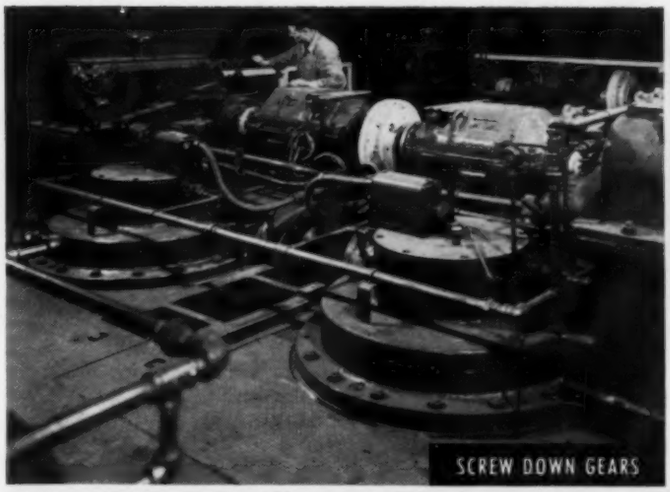

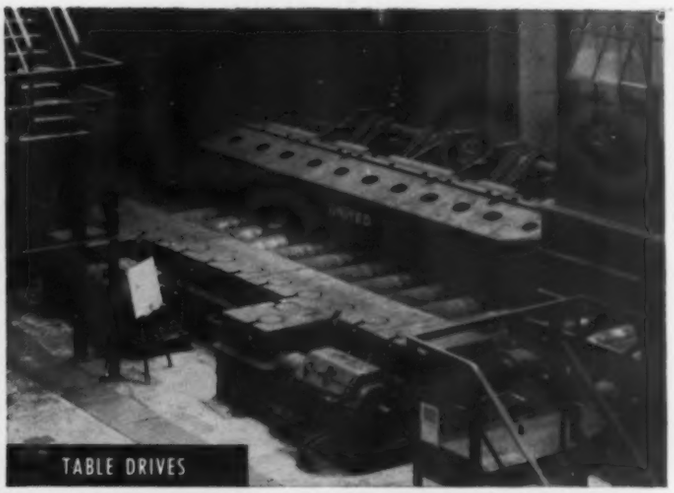

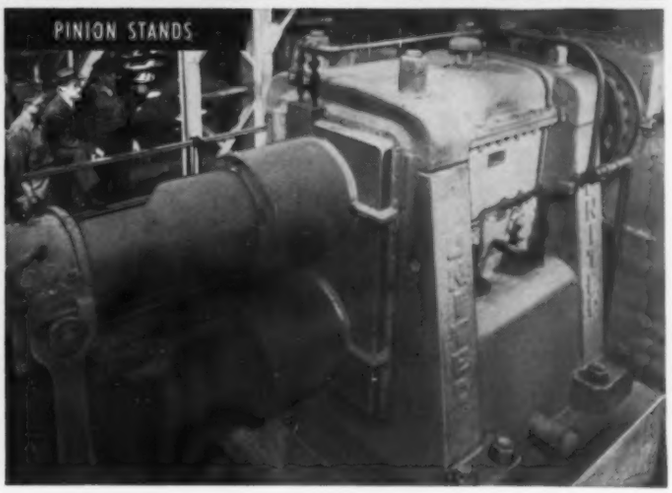

Get protection *plus* for your gear drives with GULF E. P. LUBRICANTS

Get the advantage of the extra load-carrying capacity of Gulf E.P. Lubricants, plus excellent water separating and rust preventive properties, plus exceptional stability for this type of lubricant, plus effective nonfoaming and noncorrosive characteristics.

This "plus protection" of Gulf E.P. Lubricants not only prevents excessive gear wear but insures freedom from rust, foaming, and other lubrication troubles.

The next time you order gear drive lubricants, make it an order for safe, sure protection and lower maintenance costs — specify Gulf E.P. Lubricants.

For more complete information, or for expert help on your gear drive lubrication problems, send the handy coupon.

GULF

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1822 Gulf Building, Pittsburgh 30, Pa.

Gentlemen:

I would like further information on Gulf E.P. Lubricants:

☐ Please have a Gulf Sales Engineer call. ISE

☐ Please send me a copy of your pamphlet "Gulf E. P. Lubricants for Reduction Gear Drives."

☐ Please arrange to show a group in our plant the Gulf Color Slide Film, "Gears and Their Lubrication."

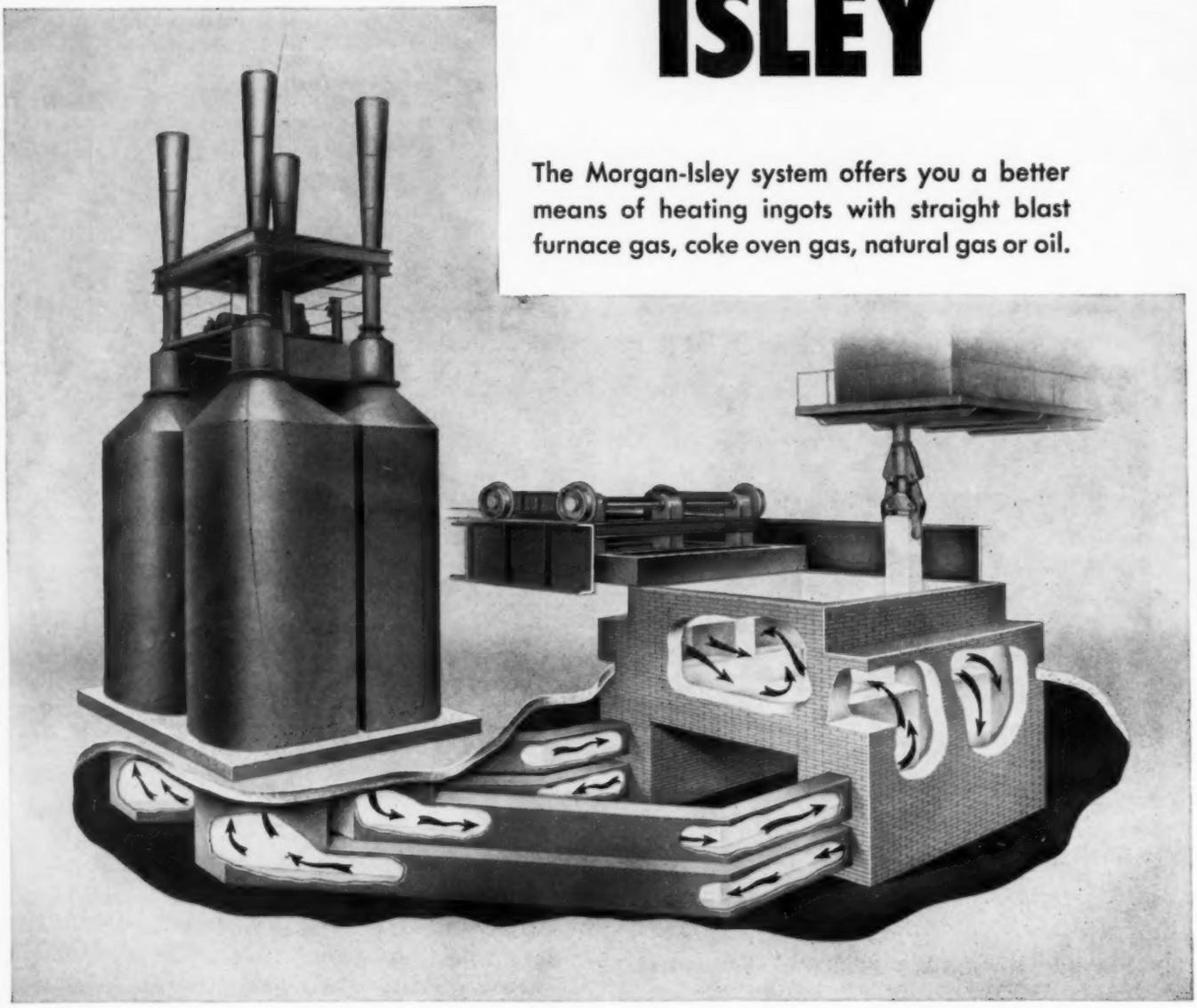
Name_____

Company_____

Title_____

Address_____

HEAT MORE STEEL with MORGAN-ISLEY



The Morgan-Isley system offers you a better means of heating ingots with straight blast furnace gas, coke oven gas, natural gas or oil.

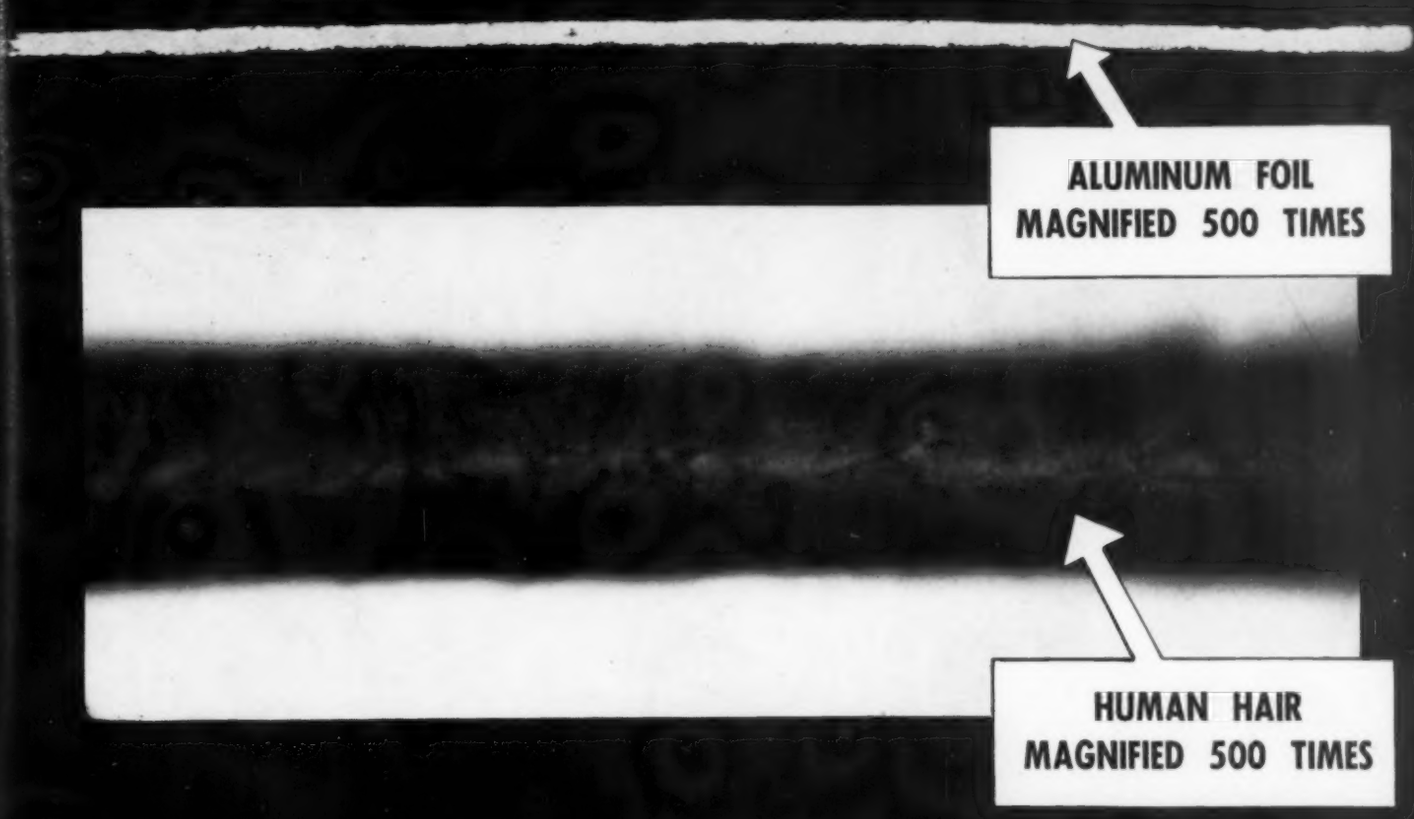
The schematic shows the flow of combustion air and flue gases through the regenerators and soaking pit. The Morgan-Isley system employs vertical regenerators. It eliminates regenerator capacity under the crane runway thus freeing this valuable area for heating steel.

CCC-49

MORGAN CONSTRUCTION COMPANY WORCESTER, MASS.

ROLLING MILLS • MORGOIL BEARINGS • REGENERATIVE FURNACE CONTROLS • EJECTORS • PRODUCER GAS MACHINES

H.H. Wood, Representative, Koppers Building, Pittsburgh, Pennsylvania



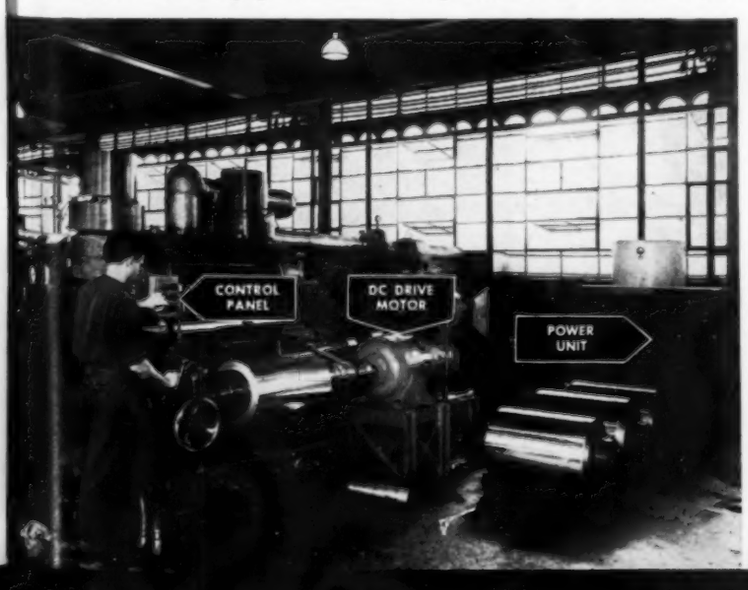
General Electric d-c drives help

Roll aluminum 1/10 the thickness of human hair

A GENTLE TOUCH—Rolling high-quality aluminum to 1/10 the thickness of a human hair takes a gentle touch. Doing it 24 hours a day, six days a week demands sturdy, reliable equipment. To obtain this combination of sensitivity and dependability Republic Foil and Metal Mills, Danbury, Conn., has installed five General Electric Speed Variators on their pay-off drives.

REDUCED DOWN-TIME—Mr. James D. Post, Vice President in Charge of Operations, reports, "The General Electric Speed Variators provide more constant tension and steady acceleration. As a result, down-time and maintenance have been reduced on this delicate work. We also like the way they stand-up under continuous operation. Our satisfaction is manifest in a duplicate order for our No. 5 mill."

THREE COMPONENTS of G.E.'s Speed Variator are shown installed on the pay-off drive at Republic Foil and Metal Mills.

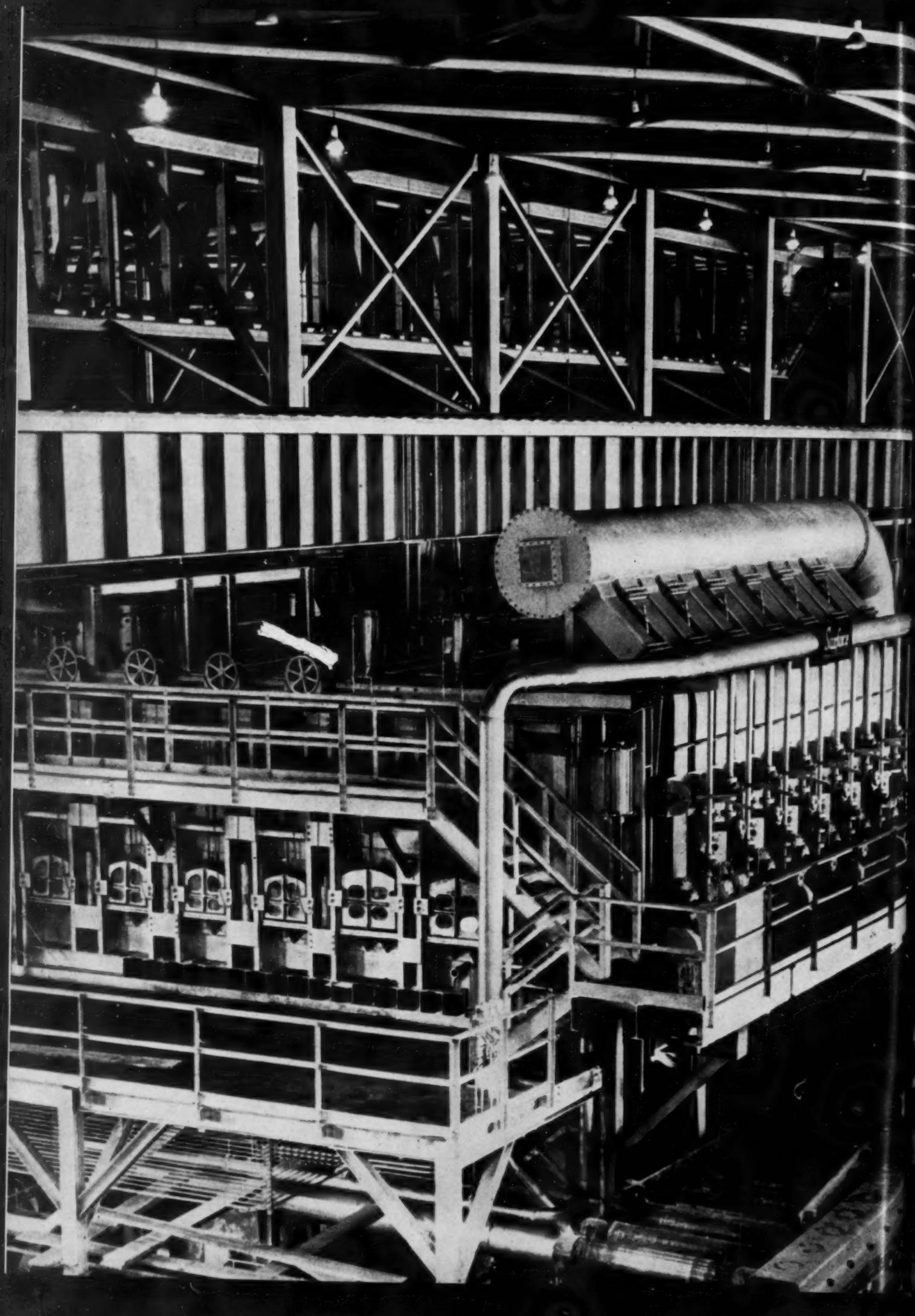


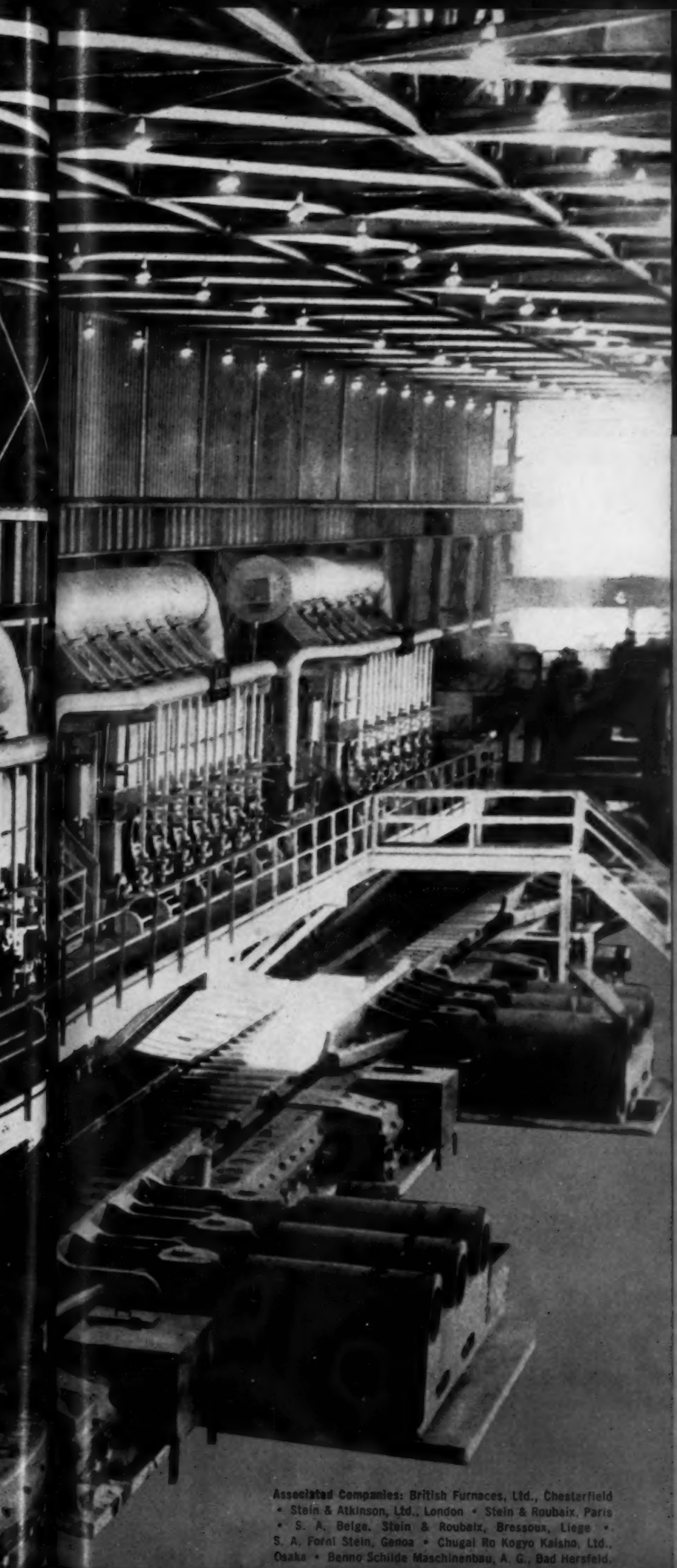
SPLIT-SECOND RESPONSE—General Electric Speed Variators are proving the answer to a variety of difficult metal rolling and slitting applications in brass, aluminum, and steel. Providing smooth, steady acceleration and split-second response to control signals, they can meet the most exacting drive requirements.

ENGINEERED TO YOUR SPECIAL NEEDS—The Speed Variator conversion unit comes assembled, wired and tested... ready to be installed on your a-c system. General Electric engineers will be glad to help you in making the most effective use of these drives. Please call your G-E Apparatus Sales Office or write for bulletin GEA-6127. *Direct Current Motor and Generator Department, General Electric Company, Erie, Pennsylvania.* 820-2

Progress Is Our Most Important Product

GENERAL ELECTRIC





200 TONS AN HOUR CONTINUOUSLY

200 tons of steel slabs are heated to rolling temperature every hour, continuously, in each of these Surface monsters—world's largest slab furnaces.

No other furnace today can list all of these features:

1 Cantilever skid supports* permitting unobstructed combustion space for underfiring.

2 Furnace lines and burner design which provide high heat input from the moment the slab enters the furnace.

3 Built-in control* to prevent intermingling of gases from upper and bottom zones, providing better control of heat application, and preventing overheated slab end.

4 Anticipatory control which reduces temperature head when rate of slab discharge decreases.

5 Air preheat up to 1100°F.

6 Television signal to pusher pulpit, informing operator of the exact position of the leading slab.

About the only conventional feature in these giants is the fact that the slabs are pushed in one end and out the other.

This is another demonstration that, at Surface, unconventional thinking and conventional experience are a productive team for the steel industry. Surface Combustion Corporation, Toledo 1, Ohio.

*patents pending

Surface
STEEL MILL EQUIPMENT

Associated Companies: British Furnaces, Ltd., Chesterfield • Stein & Atkinson, Ltd., London • Stein & Roubaix, Paris • S. A. Belge, Stein & Roubaix, Bressoux, Liege • S. A. Forni Stein, Genoa • Chugai Ro Kogyo Kaisha, Ltd., Osaka • Benno Schilde Maschinenbau, A. G., Bad Hersfeld.

Even truer today

We ran this **B&W Insulating Firebrick** advertisement in 1947

24 years now

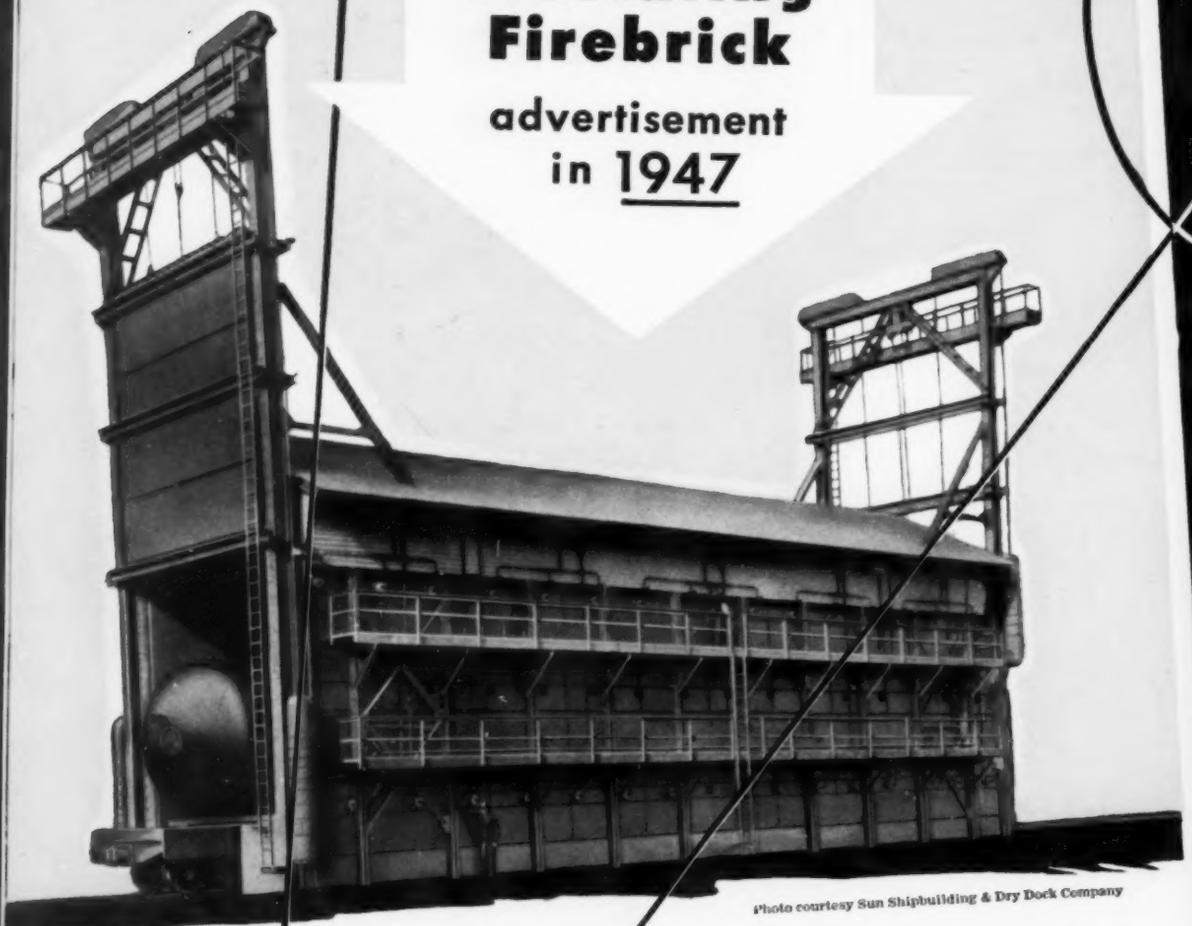


Photo courtesy Sun Shipbuilding & Dry Dock Company

Only in main arch approximately 2 feet from each end of the furnace

The furnace that PAID FOR ITSELF MANY TIMES OVER

Still lined with its original B&W Insulating Firebrick after 15 years of normalizing and stress-relieving service, this furnace is giving exceptional performance. Despite the added strain of the rigorous war years, the 80,000 B&W IFB used to line sides, ends and arch have required no appreciable maintenance!

It is no wonder the operators can report:
"This furnace has paid for itself many times over."

For furnace performance that assures highest production at lowest cost, even after years of grueling service, you can always count on lightweight B&W Insulating Firebrick. Your local B&W Refractories Engineer will be glad to help you select economical B&W Refractories for your furnaces.

B&W REFRACTORIES PRODUCTS:

B&W Allmul Firebrick • B&W 80 Firebrick •
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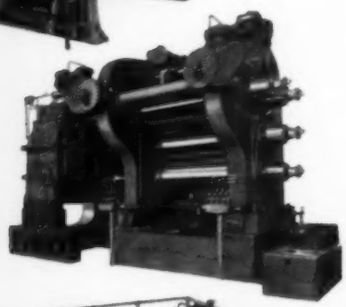

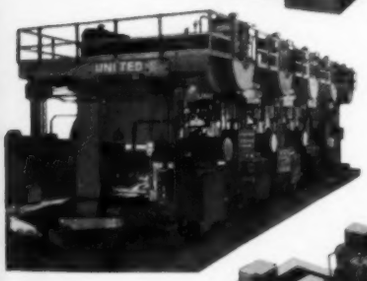

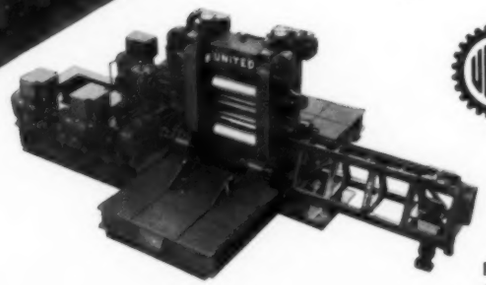

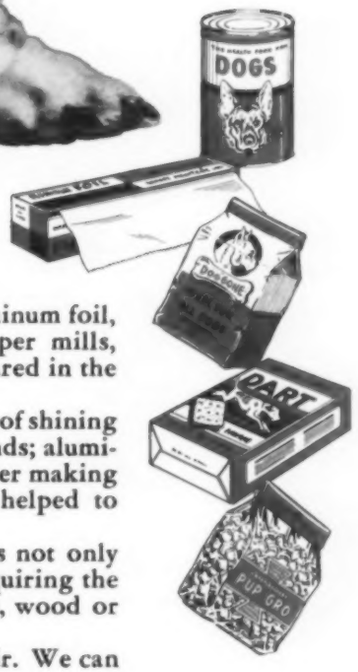

And a doggoned good one, too! Last year he gave the industry that supplies his nourishing meals,orders for 2,107,500 tons of prepared dog foods. To package all that required hundreds of tons of tinplate, aluminum foil, plastics film and paper products. Rolling mills, paper mills, plastics manufacturers, and the various fabricators, shared in the order right down the line.

We did too, because we build mills that roll out strips of shining tinplate a mile or more in length in less than 60 seconds; aluminum foil mills; plastics processing equipment, and paper making machinery. Some of our equipment most certainly helped to fill that order.

United Mills and equipment can help you fill orders not only for packaging, but for any purpose under the sun requiring the processing of steel, aluminum, copper, brass, plastics, wood or paper products.

Call us when modernization or expansion is in the air. We can be of help.

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ENGINEERING AND FOUNDRY COMPANY

Pittsburgh, Pennsylvania

Plants at Pittsburgh, Vandergrift, Youngstown, Canton, Wilmington (Lobdell United Division)
SUBSIDIARIES: Adamson United Company, Akron, Ohio
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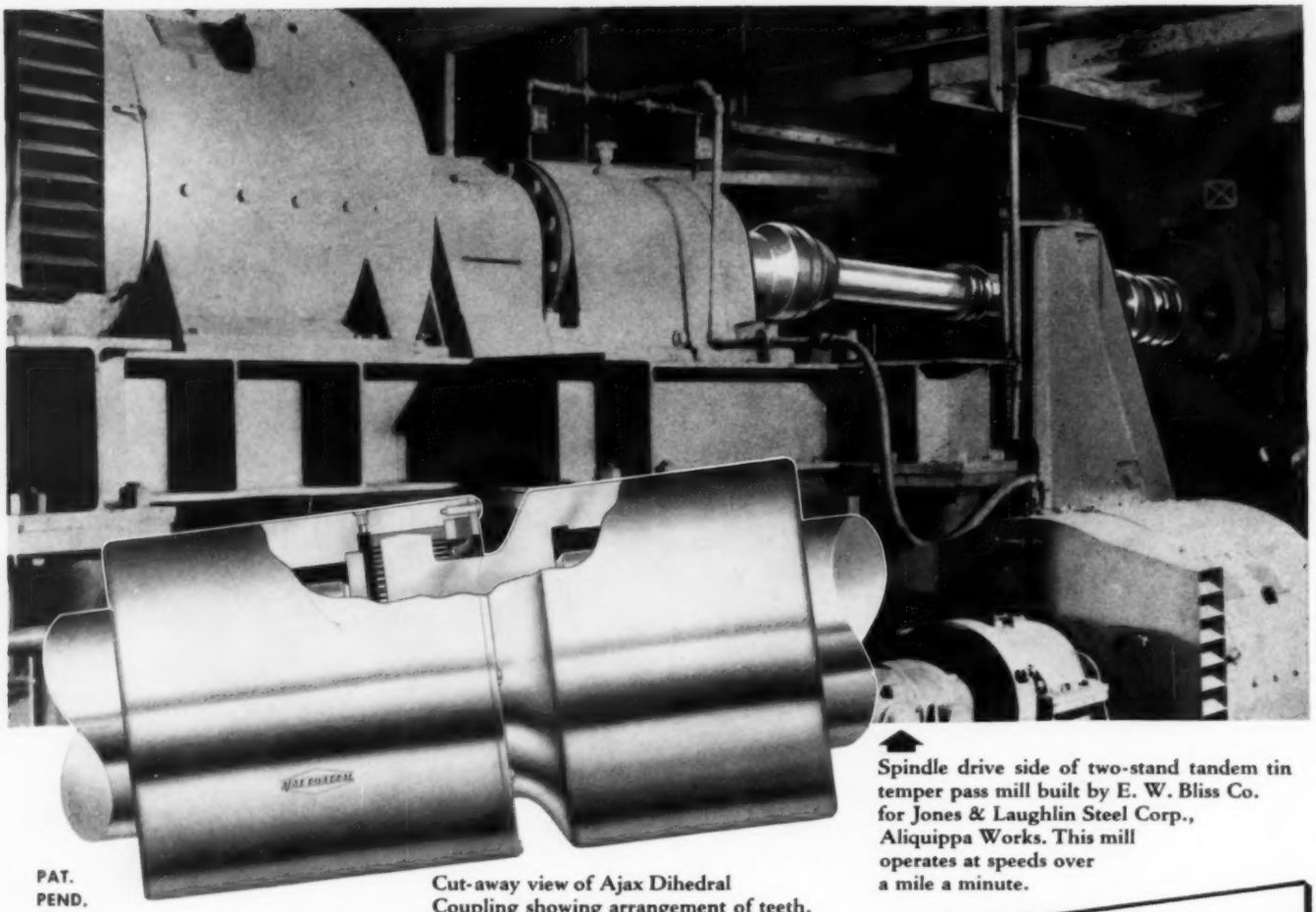
Designers and Builders of Ferrous and Nonferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other heavy machinery. Manufacturers of Iron, Nodular Iron and Steel Castings and Weldments.



PAT. PEND.

Cut-away view of Ajax Dihedral Coupling showing arrangement of teeth.

Spindle drive side of two-stand tandem tin temper pass mill built by E. W. Bliss Co. for Jones & Laughlin Steel Corp., Aliquippa Works. This mill operates at speeds over a mile a minute.

new FIRSTS *are being made with*

AJAX DIHEDRAL COUPLINGS

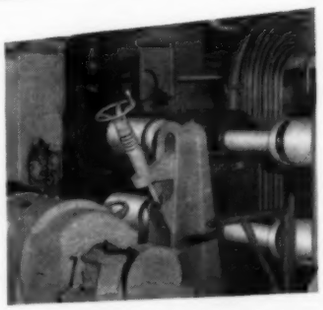
in mill after mill

Designers and users of modern mills are achieving new high speeds (up to 7200 feet per minute), new high uniformity of gauge, new high quality finish and new high production and maintenance economies. Ajax patented dihedral tooth design is revolutionizing spindle shaft drives. Ajax Dihedral Spindle Shaft Couplings are the talk of hard-boiled steel men everywhere. Write for the facts.

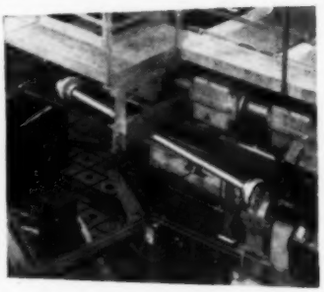
AJAX FLEXIBLE COUPLING CO. INC.

Westfield, N. Y.

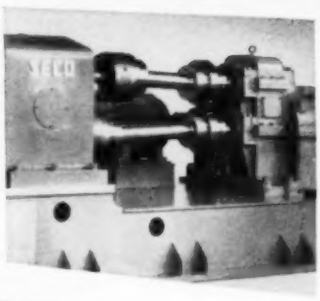
This 37″ x 80″ 2-high temper pass mill is cutting tonnage costs in the Fairless Works of the U. S. Steel Corp. at Morrisville, Pa.

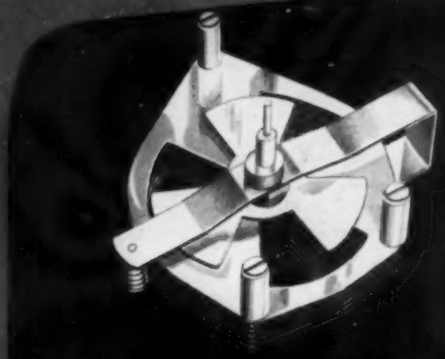


Ajax Floating Shaft Dihedral Couplings solve angular drive problems on tilting tables for the Green River Steel Corp., at Owensboro, Kentucky.



Two Ajax Dihedral Floating Shaft Couplings driving SECO 48″ heavy duty slitter in operation at McLouth Steel Co., Detroit, Michigan, cutting ¼″ stainless steel at 100 ft. per min. with 16″ diameter knives.





In DYNALOG Instruments, a simple, radio-type, variable capacitor replaces the troublesome slidewire — gives unmatched smoothness of balancing.

this
potentiometer
has
no slidewire

STEPLESS CAPACITY-BALANCING PROVIDES SPEED WITHOUT WEAR!

Friction-free balancing action! That's why Dynalog responds almost instantly to the slightest changes in a process variable . . . without wear . . . with *lasting* high accuracy.

The DYNALOG has no fast-moving parts . . . and no gears, cables, or complicated mechanisms to slow response. Sensitivity isn't limited by slidewire windings. A simple, variable capacitor and positive magnetic drive provide continuous, stepless balancing with a sensitivity of 1/100 of 1% . . . an accuracy of ¼ of 1%. And DYNALOG is never "off process" for standardizing — it requires *none*. There are no batteries to replace . . . no motors to periodically clean and lubricate. Only five moving parts!

DYNALOG Instruments can be used with resistance, voltage, capacity, or inductive type primary elements to measure and/or control any process variable with unmatched speed and accuracy. Write for Bulletin 427. The Foxboro Company, 588 Neponset Ave., Foxboro, Mass., U.S.A.

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DYNALOG's*
EXCLUSIVE BALANCING ACTION

- no slidewire
- no batteries
- no standardizing
- no gears, cables, etc.
- no high-speed reversing motor

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DYNALOG
ELECTRONIC INSTRUMENTS

ONE OF A SERIES . . .

What makes a cylindrical roller bearing good?

SUPERIOR QUALITY of INNER RACES

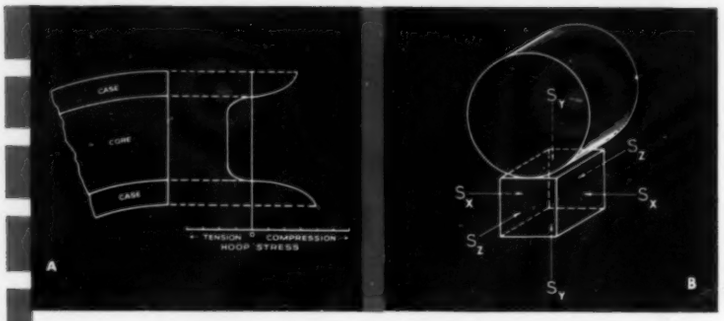
The function of an inner race is to provide a fatigue-resistant surface between a shaft and the bearing rollers. Because of roller bearing geometry, there is a smaller area of contact between inner race and rollers than between outer race and rollers. This concentrates more load on the inner race and makes it the critical member from a fatigue life standpoint, particularly when the inner race is the stationary member and maximum load is repeatedly applied at one point.

Since it is vital to good performance that the inner race does not work loose on the shaft, HYATT inner races are designed for relatively heavy press fits, so the inner race becomes an integral part of the shaft for all practical purposes. Other advantages of HYATT'S carburizing process and precision finishing operations are briefly explained at right.

You'll find more details in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type best suited to your design requirements. Remember, HYATT is America's *first* and *foremost* maker of roller bearings. Hyatt Bearings Division of General Motors Corporation, Harrison, New Jersey.

GM GENERAL MOTORS

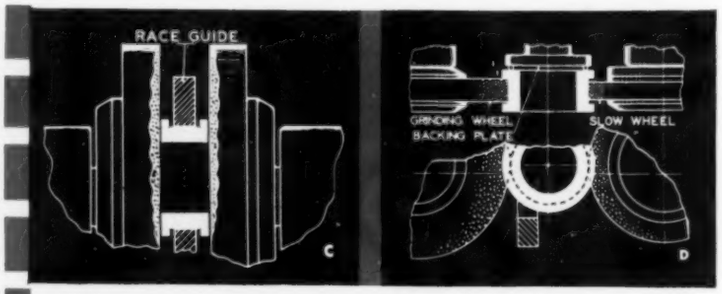
HYATT ROLLER BEARINGS



1. WHY CARBURIZING?

Carburizing provides inner races with tough cores, and flanges that will not crack, with no loss of case hardness. This permits tight press fits and also improves load-carrying capacity as shown in Diagram A. During quenching, a volumetric change tends to stretch the core and compress the case. Due to the Poisson effect, the compressive hoop stresses in the external fibres build up the load-carrying capacity.

Diagram B shows a typical element under roller load. Stresses in the "Z" direction are negligible; those in the "X" direction are compressive hoop stresses or pre-load. Those in the "Y" direction are compressive stresses due to the load. Without the compressive stress Sx (hoop stress) the load capacity would be reduced; and if "X" were a tensile stress due to pressing a through-hardened race on a shaft, the bearing capacity would be still less.

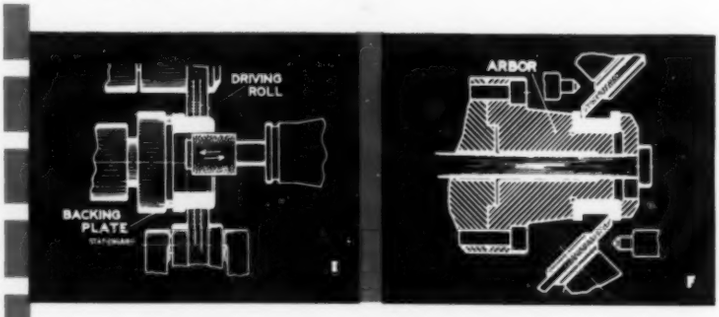


2. DOUBLE END GRIND

In grinding a HYATT inner race, the ends are first faced off square and parallel so they can be used as accurate reference during subsequent operations. The HYATT double end grind process (Diagram C) insures excellent control of parallelism.

3. CENTERLESS PATHWAY GRIND

Centerless grinding was pioneered by HYATT years ago, and eliminates excessive wall variation due to spindle and chucking errors. This method produces as nearly a perfect cylinder as is commercially practical. Two-point and three-point out of round and taper are held to a minimum. Note how work is rotated with backing plate against previously ground end (Diagram D) to insure accuracy.



4. CHUCKLESS BORE GRIND

Here the centerless method assures a bore concentric with the pathway, with minimum wall variation, by removing stock from high spots as they pass between drive roll and related grinding wheel (Diagram E).

5. FLANGE GRINDING

To assure that they will run true with roller pathway, flange faces are also ground using the squared ends for reference (Diagram F). This establishes even contact with roller ends during bearing operation.

By MELVIN NORD, Patent Attorney, Detroit, Mich.

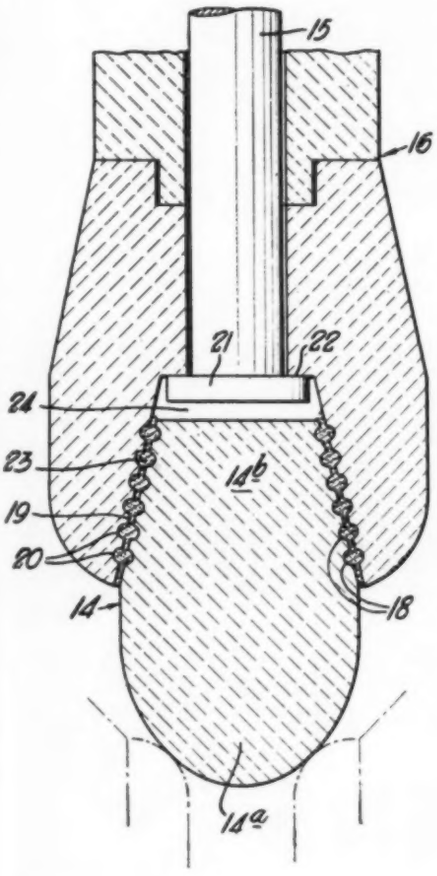
Patent Reviews

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period March 6, 1956 through March 27, 1956 . . . .

STOPPER ROD WITH SOLID HEAD

▲ U.S. 2,736,935, issued March 6, 1956 to James A. Shea and assigned to United States Steel Corp., provides a stronger stopper rod for ladles, which prolongs its life.

Figure 1



As shown in Figure 1, the head 14 is a solid body unbroken by passageways for receiving a mechanical connector, e.g. the stopper rod or head pin. The lower refractory sleeve 16 contains a flared counterbore 19 containing grooves 20. The head 14 also contains similar grooves 18. A refractory cement 23 fills the grooves 18 and 20, thus cementing the head 14 to the sleeve 16. The sleeve 16 is supported by a flange 21 at the bottom of the rod 15. The upper face of the head is insulated from the bottom face of flange 21 by an air gap 24 so that the graphite head cannot carburize the rod.

SEPARATION OF MANGANESE FROM IRON ORES

U.S. 2,737,441, issued March 6, 1956 to Ernest S. Nossen, describes a process for separating manganese from iron ores containing about 10 per cent manganese, 20 to 30 per cent silica, and less than 50 per cent iron. The process also results in the beneficiation of the iron ore to a product containing more than 50 per cent iron.

The crushed ore is incompletely reduced, so that Mn_2O_3, MnO, and Fe_3O_4 are present in the ore. This product is leached with nitric acid, so as to extract a greater part of the manganese due to its solubility. The iron remains in the residue since Fe_3O_4 is not soluble. The manganese nitrate is then decomposed by heating in the presence of air, yielding MnO_2 and nitric acid. The Fe_3O_4 concentration in the solid residue may be increased by magnetic separation.

PRODUCING INGOTS OF KILLED STEEL IN BIG-END-DOWN MOLDS

U.S. 2,737,696, issued March 13, 1956 to Bruce M. Shields and assigned to United States Steel Corp., describes a method of treating fully killed steel cast in big-end-down molds so as to produce sound ingots with high yield.

As shown in Figures 2 to 5, a conventional big-end-down ingot mold 10 rests on stool 11 and has a cavity 12 in it, which tapers slightly toward the top. A hot-top 13, placed on the upper end of the mold, projects a substantial distance down into the mold. It has lugs 14, resting on spacer blocks 15 on top of the mold. The mold is designed to form an ingot 12a of height H and width W where H/W is between 2.7 and 3.2. If the ratio is more than 3.4, there is serious risk of the formation of secondary pipe. A ratio within these limits practically eliminates secondary pipe.

Fully killed liquid steel is teemed into the mold 10 until it rises to a predetermined height above the bottom of the collar 13, as shown at 16 in Figure 3. This height should be such that the volume of metal initial-

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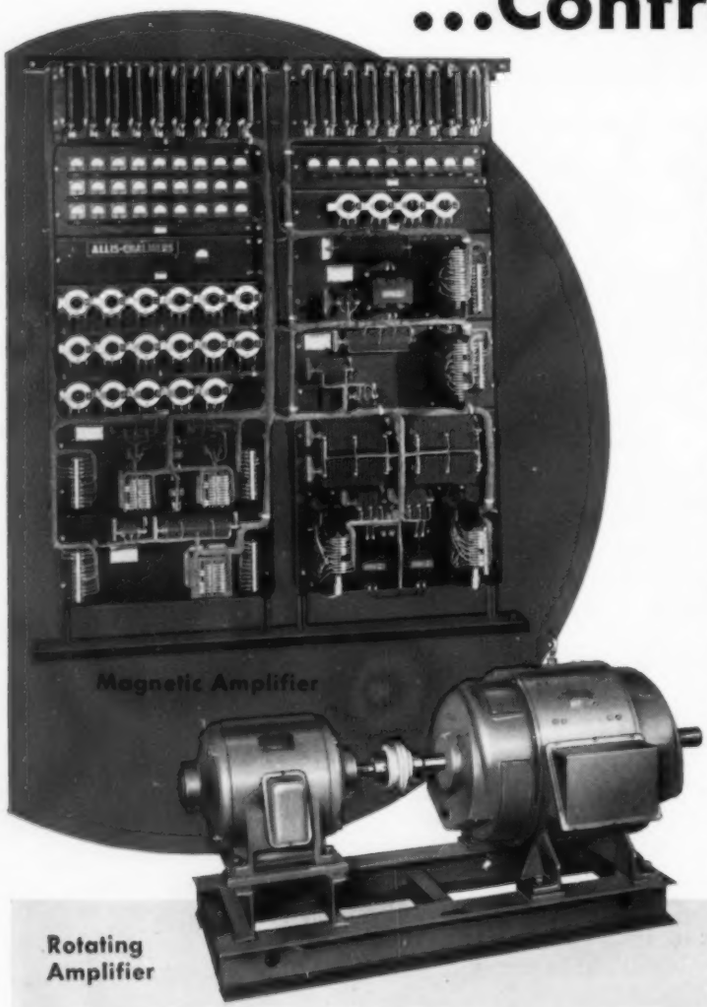
...More Mill Production ...Control Over Quality



Rotating Amplifier

The most important factor in meeting the challenge of more tonnage and improved quality is effective regulation. And effective regulation is more than a matter of good regulator design. It embraces overall *system* design . . . the integration of generators, exciters, motors, regulators and other control equipment. As manufacturer of all these interdependent components, Allis-Chalmers is in a unique position to provide this practical approach to mill regulation.

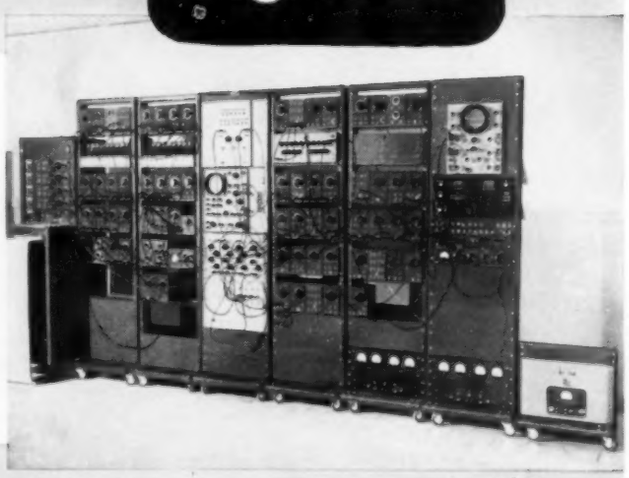
"Coordineered" System

Allis-Chalmers maintains separate departments, staffed by specialists, for each product. "Coordineering" results from an interdepartment exchange of ideas and technical information correlated in *one* department specializing in metals-producing industry application. All components are matched to meet the requirements of your job. Responsibility for system performance rests with one company.

For complete information, see your Allis-Chalmers representative or write Allis-Chalmers, General Products Division, Milwaukee 1, Wis.

A-5029

ALLIS-CHALMERS
Regulators



Three Types of Regulators Available

The following types of regulation are "coordineered" into an Allis-Chalmers system:

1. ***Regulex* Rotating Amplifier** — Applicable where high power levels for reversible output are desired.
2. **Magnetic Amplifier** — Applicable where low power levels for reversing or high power levels for non-reversing are desired.
3. **Combinations of *Regulex* Rotating and Magnetic Amplifiers** — Each complements the other for maximum efficiency.

Analytical Facilities Utilized...

System performance is simulated in the computers to get optimum configuration of components. The constants and exciter ceilings necessary for desired response are established.

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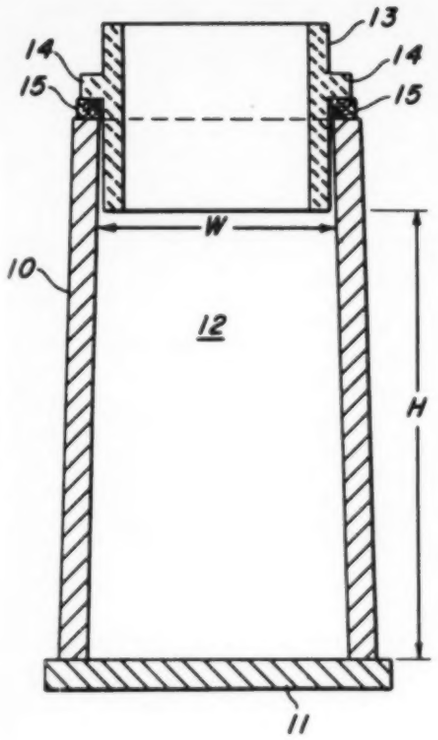


Figure 2

ly present in the hot-top is about 6 per cent of the volume of the ingot proper. A sinkhead volume less than 5 per cent will usually not provide sufficient metal to completely fill the shrinkage cavity. More than 10 per cent is practically never needed.

As soon as the mold has been filled, a small amount of insulating material 17 is spread on the surface of the sinkhead so as to permit the initial formation of only a thin crust of solid metal at the surface, thus keeping the interior molten for a substantial period.

The ingot then cools until it has all solidified except the central portion. As pipe tends to form, it is filled by liquid metal flowing down from the upper portion of the ingot, which is replaced by metal from the sinkhead, leaving a void 19 in it, as shown in Figure 4. At this time, additional heat is supplied to the sinkhead, so as to remelt the portion 20 which has solidified. The heat may be supplied by depositing a thermite-like mixture.

When the remelting of the sinkhead has occurred, the greater part of it is absorbed into the ingot proper, as shown in Figure 5. An additional cooling period of about a half hour is required before stripping.

The yields obtained average about 88 per cent. The ingots are satisfactory insofar as the macro-etch test and analysis for segregation are concerned. The ingot is free of pipe and porosity and equivalent in quality to a big-end-up ingot.

SALT BATH SYSTEM FOR CLEANING METAL SURFACES

U.S. 2,738,293 and 2,738,294, issued March 13, 1956 to Harry R. Spence and assigned to Diamond Alkali Co., describe new alkaline salt bath systems for removing oxides from the surface of metals.

The first patent uses 70 to 98 per

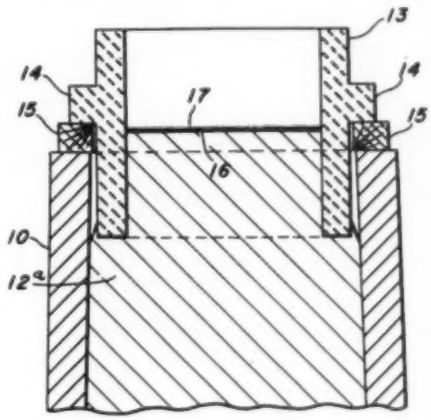


Figure 3

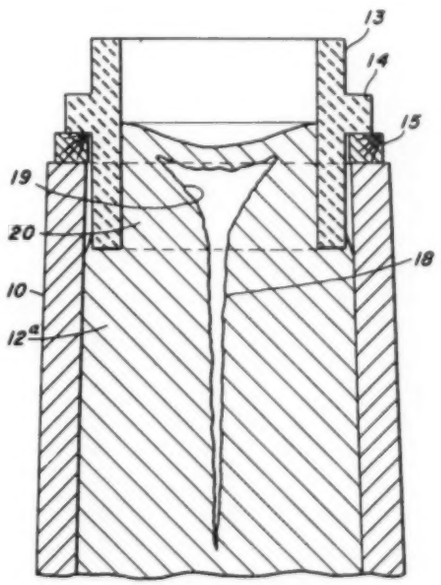


Figure 4

cent sodium hydroxide, and 0.5 to 12 per cent potassium hydroxide, the balance being an oxidizing agent such as sodium nitrate. This mixture prevents excessive removal of metal, and in the case of stainless steel avoids preferential action on the oxides in favor of the chromium oxide.

The second patent uses 70 to 95 per cent sodium hydroxide, 0.5 to 12 per cent potassium hydroxide and 0.5 to 20 per cent $BaCl_2$. The inventor claims that this salt bath resists oxidation and contamination for greater periods of time than usual.

TREATMENT OF WASTE PICKLE LIQUOR

U.S. 2,739,040, issued March 20, 1956 to Edgar B. Mancke, and assigned to Bethlehem Steel Co., describes a process of regenerating sulphuric acid by treatment of waste pickle liquor at 250 psi pressure and 350 F, in the presence of an oxidizing agent. Under these conditions, iron is precipitated as basic iron sulphate. The free acid is then separated from the precipitated iron compound.

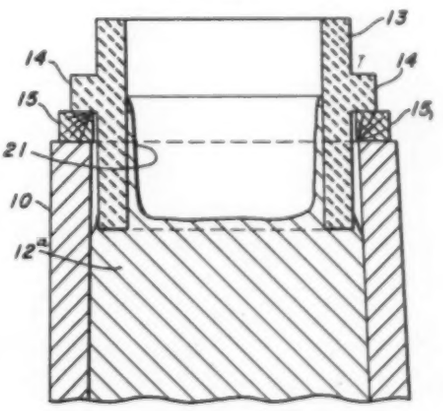
REDUCTION OF IRON ORE WITH METHANE

U.S. 2,739,055, issued March 20, 1956 to Hans Gallusser and assigned to Ateliers Des Charmilles S. A., describes a process for reducing iron ore with methane in a vertical stack type furnace.

In Figure 6, the mid-section b of the shaft furnace 10 is provided with a heating system so as to maintain a temperature of 800 to 1000 C. Reduction of the iron ore takes place in zone b. Heating may be accomplished by electric resistance, induction heating, or external gas heating. In space 14, the hot gases heat the incoming cold ores. In space 15, the hot solids are cooled by the inflowing cold circulating gases.

The methane is introduced into zone b through line 16. Cold circulating gas, consisting of H_2 and CO is introduced at the bottom through line 17. In the bottom of zone b, reduction of the iron ore begins, along

Figure 5



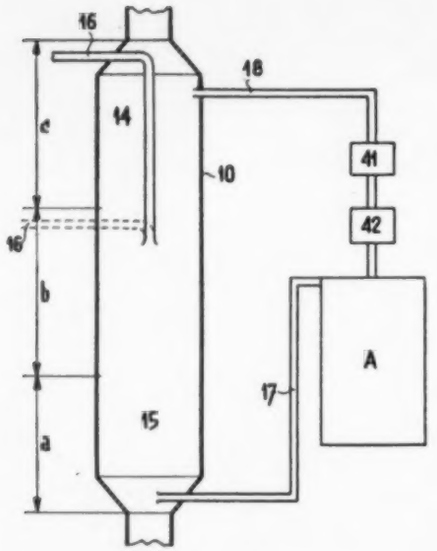


Figure 6

with the formation of water vapor and CO_2 from the hydrogen and CO of the circulating gas. The methane enters at a place where there is already sufficient water vapor in the circulating gas to decompose it to CO and H_2, i.e.

$$CH_4+H_2O\rightarrow CO+3H_2$$

These newly formed gases participate in the reduction until chemical equilibrium is established between H_2, H_2O, CO, and CO_2. Before leaving the furnace, these gases heat the incoming ore and are therefore cooled. They are then sucked by a compressor 41 through line 18 and passed to a cooler 42, where the water vapor is condensed. The gases are then treated in a washing plant A to remove CO_2. The remaining cold gases, H_2 and CO, are then recycled to the bottom of the furnace.

The patent describes several methods of heating the furnace, in some detail.

EXTRACTING IRON FROM ORES

U.S. 2,739,056, issued March 20, 1956 to Karl Heimberg and assigned to Compagnie Generale des Conduites d'Eau, describes a process of extracting iron from acidic ores which are relatively poor in iron content. A cupola furnace is used in conjunction with blast furnace, to produce low sulphur-containing iron.

The ore is smelted in a blast furnace, to form a slag having a low sulphur content, and a pig iron having a high sulphur content. These are separated from each other, and the pig iron is charged to a cupola furnace. The pig iron is melted in the cupola under reducing conditions (excess carbon being present in the furnace), and is passed in the molten state through a molten basic slag in the cupola, thereby obtaining iron having a low sulphur content.

INSPECTION DEVICE FOR MOVING STRIP

U.S. 2,739,503, issued March 27, 1956 to Henry W. Nieman and George O. Maish, assigned to Bethlehem Steel Co., describes a shielding mechanism for use in connection with a photo inspection device for strip metal stock to be used in the production of tinplate.

The object of the invention is to provide edge shields which prevent the passage of light around the edges of the strip. This makes it possible to inspect the strip to within a very small distance from the edges.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,737,270	3/ 6/56	A nailing I-beam	Great Lakes Steel Corp.
2,737,272	3/ 6/56	Pneumatic brake and throttle system	United States Steel Corp.
2,737,298	3/ 6/56	Waste disposal of cyanides	Wigton-Abbott Corp.
2,737,455	3/ 6/56	Ferritic creep-resisting steels	Thos. Firth & John Brown, Ltd.
2,737,481	3/ 6/56	Regenerative coke oven battery	Koppers Co., Inc.
2,737,834	3/13/56	Automotive conveyor system for billets	Chrysler Corp.
2,737,912	3/13/56	Open hearth furnace arch	Didier-Werke A.G.
2,738,062	3/13/56	Glass mat cutter for steel extrusion process	The Babcock & Wilcox Co.
2,738,063	3/13/56	Device for indexing the die apertures on extrusion presses	Schloemann Aktiengesellschaft
2,738,138	3/13/56	Conveyor system for use with rolling mills	Davy and United Engineering Co. Ltd.
2,738,186	3/13/56	Apparatus for feeding strip	United States Steel Corp.
2,738,239	3/13/56	Device for preventing side play of bearing chocks	United States Steel Corp.
2,738,267	3/13/56	Hardenable stainless steel	United States Steel Corp.
2,738,268	3/13/56	Piston rings of cast iron	Tage D. Madsen
2,738,269	3/13/56	Cast iron alloy	Tage D. Madsen
2,738,295	3/13/56	Producing silicon steel laminations	Allegheny Ludlum Steel Corp. et al.
2,738,576	3/20/56	Method of producing cold work steel bar material from a coiled length of steel rod stock	Axel Frokjaer-Jensen
2,738,744	3/20/56	Furnace refractory structure and mounting	Levi S. Longenecker
2,738,886	3/20/56	Rotary cooling device for sinter	Kaiser Steel Corp.
2,739,057	3/20/56	Alloy steel of high expansion coefficient	Crucible Steel Co. of America
2,739,514	3/27/56	Piler for sheet steel	Bethlehem Steel Co.
2,739,763	3/27/56	Apparatus for coiling cold rolled strips	Sandvikens Jernverks Aktiebolag
2,739,764	3/27/56	Collapsible spooling reel	United States Steel Corp.
2,739,765	3/27/56	Collapsible reel	National-Standard Co.
2,739,799	3/27/56	Charge-discharge mechanism for billet heater	Babcock & Wilcox Co.
2,739,800	3/27/56	Controls for pelletizing furnace	Erie Mining Co.

WANTED!

There is a constant demand for copies of "The Modern Strip Mill," published by the Association of Iron and Steel Engineers.

If your copy is not in use please get in touch with us.

ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

NEWMAN-CROSBY STEEL HAS RAISED ITS CAPACITY 40%

with this new BLISS mill

Like many another metal producer, Newman-Crosby Steel Company is betting confidently on the continued healthy growth of the American economy! This Rhode Island producer of close-gage cold rolled strip has just raised its capacity a good 40% by installing a new Bliss 4-high reversing mill, as well as new coil-handling and heat-treating facilities.

The 6½″ and 16″ x 14″ mill is used to roll high-carbon and alloy spring steel in gages between 0.125″ and 0.010″, in widths up to 12″ and at speeds to 800 fpm. In actual operation all these design specifications have been exceeded. Bliss also designed and built the coil-handling facilities, including the two tension reels and coil buggies and the pay-off reel. Maximum limit on coil weight is 6,000 pounds.

An unusual roll drive arrangement permits wide flexibility in the choice of roll diameter. Roll speeds are synchronized electrically rather than through gears. Thus, even unmatched roll diameters can be used together successfully.

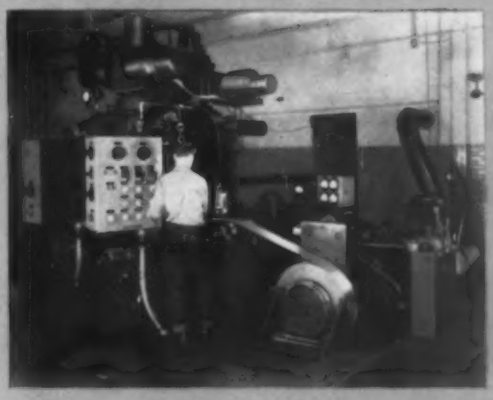
Building mill equipment to meet special needs . . . or to perform standard operations more efficiently . . . is an important reason why Bliss has become a leader in the field. If you would like more information on Bliss mill innovations, as well as details of many Bliss installations, write us today for a copy of our 60-page Rolling Mill Brochure, Catalog 40-A.

E. W. BLISS COMPANY
General Office: Canton, Ohio
ROLLING MILL DIVISION
SALEM, OHIO

BLISS
SINCE 1857

is more than a name...
it's a guarantee

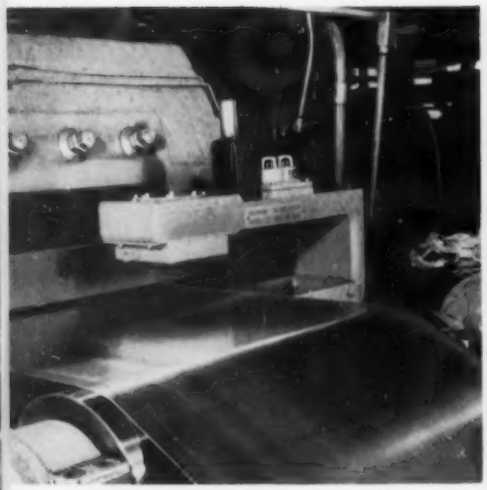
The new mill has already outperformed most of the specifications set for it, rolling strip thinner, wider and faster than its original objectives of 0.010-inch gage, 12-inch width and 800 fpm speed.



Another view of the unusual new mill. Elimination of geared roll drive adapts it to use with wide variety of roll diameters to suit different rolling problems.

PLANTS: Canton, Cleveland, Salem and Toledo, Ohio; Detroit and Hastings, Michigan; Pittsburgh and Midland, Pennsylvania; San Jose, California. *In Europe:* E. W. Bliss (England) Ltd., Derby; E. W. Bliss (Paris), France.

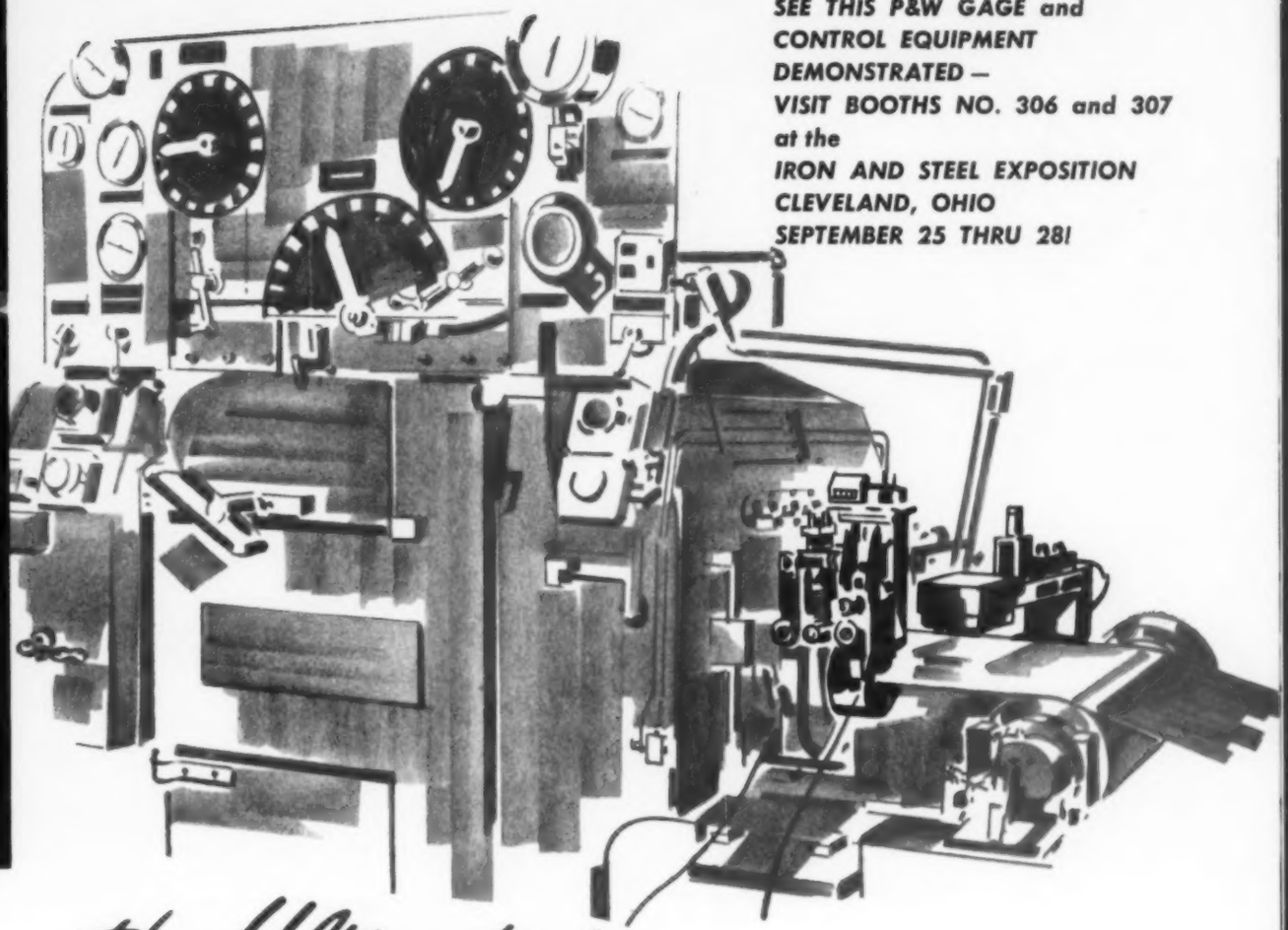
MAINTAIN MATCHLESS QUALITY
with PRATT & WHITNEY



THE X-RAY GAGES and CONTROL UNITS This is a reversing-type mill with duplicate P&W X-Ray Gages on each side. Giving continuous, extremely accurate readings, the gages are non-contacting, cannot mar the most highly finished surfaces. When the gage detects a deviation from nominal strip thickness, it transmits an impulse to the two P&W Control Units which operate to bring the strip back to size automatically. One control corrects the mill screw-down, the other adjusts the tension.

THE RECORDER and INDICATING METERS To provide the permanent production record essential to maintaining rigid, long-term control of strip quality, a P&W Direct-Reading Recorder is incorporated in the installation. This instrument continuously registers *actual strip size* in .0001" increments. As a further check, two indicators (one for each gage) are also provided. These give the mill operator a continuous reading of *strip deviation from nominal* in .00005" increments.

THE TOTALIZER and CARD PRINTER Incorporated in the Control Desk, a P&W Totalizer gives, at a glance, the totals of oversize, undersize, on-size and complete footage in each coil of strip. Providing a permanent record of these totals, a separate Card Printer is located adjacent to the desk. Following the last pass, the operator inserts a card into the Printer, and the information supplied by the Totalizer – plus the date, time, and operator's number – is automatically printed on the card.



SEE THIS P&W GAGE and CONTROL EQUIPMENT DEMONSTRATED — VISIT BOOTHS NO. 306 and 307 at the IRON AND STEEL EXPOSITION CLEVELAND, OHIO SEPTEMBER 25 THRU 28!

. . . *the Ultimate in Automation Gaging*

FROM ONE SOURCE, ONE RESPONSIBILITY

. . . COMPLETE AUTOMATIC CONTROL SYSTEMS — ENGINEERED TO MEET INDIVIDUAL REQUIREMENTS EXACTLY — FOR MODERN ROLLING MILLS

THE WALLINGFORD STEEL COMPANY of Wallingford, Connecticut, has built an enviable reputation, specializing in stainless steel strip (and tubing made from its own strip) that meets the rigid specifications of exacting customers. Because their requirements permit no compromise with the highest standards of uniform product quality, Wallingford has always invested in the finest, most advanced equipment available. So Pratt & Whitney Automation Gaging was a logical choice. Applied to Wallingford's Sendzimir Mill, this system provides continuous, non-contacting gaging *plus completely automatic* correction of the mill to maintain strip thickness within required tolerances *at all times!*

Phone the P & W Branch Office near you and request a Pratt & Whitney Gage Engineer to call and analyze your requirements . . . or write direct to Pratt & Whitney Company, Incorporated, 28 Charter Oak Boulevard, West Hartford 1, Conn.

PRATT & WHITNEY

FIRST CHOICE FOR ACCURACY

MACHINE TOOLS • GAGES • CUTTING TOOLS

Pole Star distribution transformer cores are precisely shaped by "squeezing" the laminations between the outer, riveted lamination and a hydraulically inserted annealing block. Retention of this shape is assured by controlled-atmosphere annealing, after an outer annealing form has been added as shown in the smaller photograph above.

Precision-shaping POLE STAR cores keeps exciting current and core loss uniformly low

After a Pole Star core is given its preliminary shape by forming dies, the outer lamination is riveted into position and an annealing block is inserted into the window of the core by means of the hydraulic press pictured above. By thus "squeezing" the laminations between the annealing block and the outer lamination, the core is precisely shaped in accordance with predetermined specifications for the particular size. The laminations, which had been cut to progressive lengths for telescoping of the individual pieces, are uniformly lapped.

Both the finished core shape and the uniform laps are figuratively "locked" in place by the stress annealing operation that follows. Annealing in controlled-atmosphere furnaces also insures retention of the inherent qualities of the grain-oriented steel. Any adhesions that may be formed during annealing are eliminated later, because laminations are separated from each other as they are placed in the coil and individually re-lapped.

Such rigidly controlled production means that the advantages of Pole Star's patented lap-on-top core are as consistent as they are outstanding. The individually lapped laminations create a large cross-section area at the lap that reduces the density and prevents a concentration of flux. The absence of gaps or butt joints assures a low exciting current. High interlamination resistance, plus the absence of adhesions, keeps core loss at a low value.

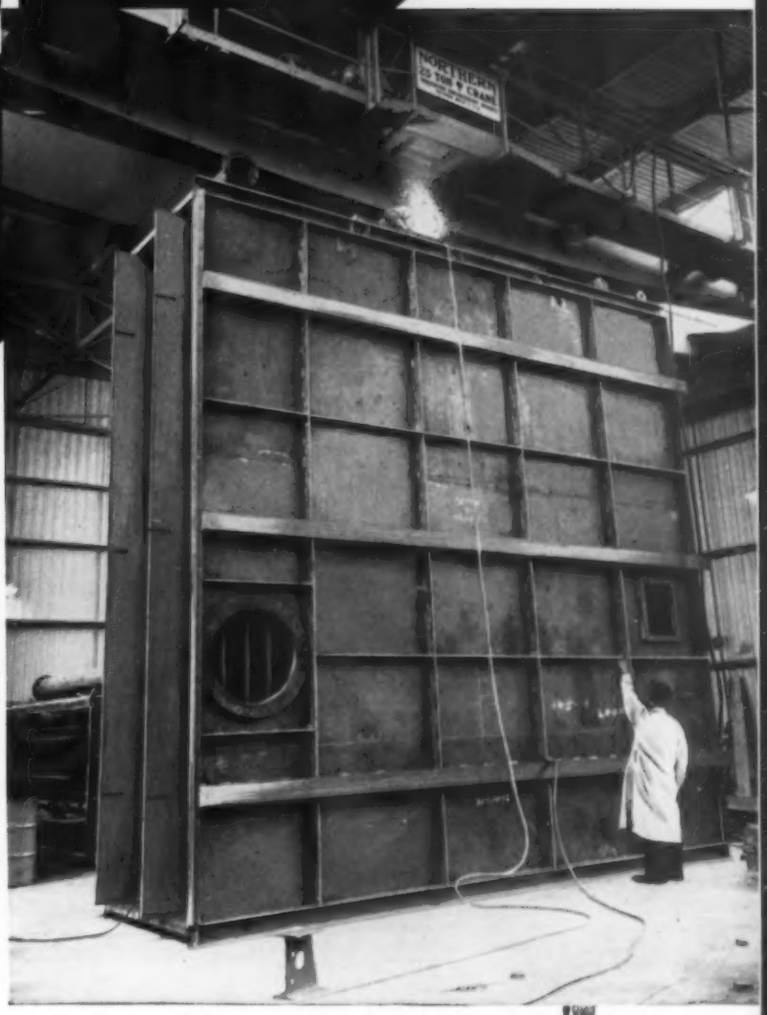
167 Production Controls make Pole Star Best!

PENNSYLVANIA TRANSFORMER COMPANY

A McGraw Electric Company Division **CANONSBURG, PA.** *Greater Pittsburgh District*

Pole Star Transformers are available in all standard single phase distribution sizes from 3 through 500 kva, through 67,000 volts.

Two Miles of Pipe in this FORTY-TON PACKAGE

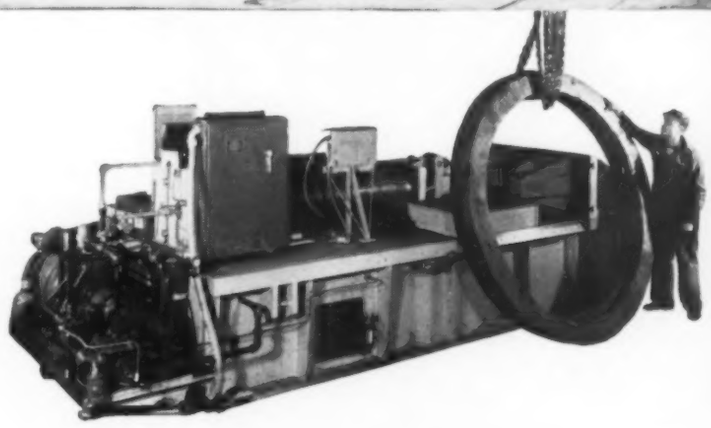


Completely Assembled, Welded and Tested by McGREGOR-MICHIGAN

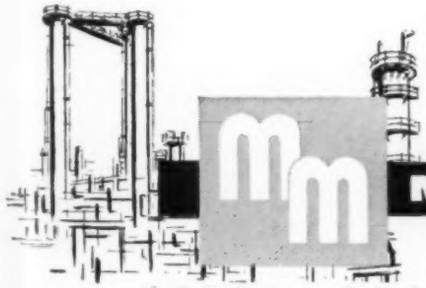
Sorry, we can't show the contents of this hefty box. It's our customer's design. But we *can* tell you each of four assemblies required approximately 10,000 lineal feet of 2″ extra heavy pipe, hydrostatically tested at 600 psi pressure. Shipment was made the McGregor-Michigan way—*on schedule*. This is one of the first sizeable jobs produced in our new Heavy Fabrication Plant which is equipped with the most modern equipment for bulkier and heavier work. Our Main Plant continues to turn out welded and riveted plate fabrications in both mild and alloy steels, such as steel mill charging buckets, ladles, furnace doors, ingot cars—chemical and petroleum processing towers, tanks, jacketed kettles—machine bases, diesel engine beds, heat exchangers, autoclaves, stacks—and an endless variety of other industrial equipment.

Something different in fabrication service is illustrated. It's our new six hundred ton horizontal press for cold-forming heavy bars, channels, conveyor rails and other structural steel members. The 67″ I.D. gear blanks shown are SAE 6150 steel, of 6″ x 6″ cross section, formed and then welded into an accurate ring. After welding, joints are cobalt-bomb x-rayed. Such equipment permits us to offer you close tolerance forming to almost any configuration with no heating or reheating (depending on nature of material), simplified dies, faster service and lower costs.

Please send prints or specifications for prompt quotation on your next fabrication job, or write for brochure illustrating our facilities and production.



New 600-ton "Bulldozer" — M-M designed and built horizontal forming press.



SINCE 1841

McGREGOR-MICHIGAN CORPORATION

5820 RIVARD • DETROIT 11, MICHIGAN

TRINITY 2-2400

STEEL PLATE FABRICATING AND WAREHOUSING

More Features of EC&M TYPE SW ALL-WELDED LIFTING MAGNETS Assure More Dollar Value

EC&M Type SW ALL-WELDED Lifting Magnets have a new look . . . inside as well as outside. Stronger, better designed to withstand the hard knocks encountered in magnet operation, they are easier to maneuver, and through high lifting capacity they reduce handling costs.

The magnet-coil is wound between turns with purer, thinner asbestos tape, with its strength increased by impregnation with EC&M No. 281 compound. Between layers, the insulation is a new product—ECAMICA board which is moisture-free, has high dielectric strength and excellent mechanical ability. A new fabricating process locks the windings against movement.

Look at the features pictured here in the top and bottom views of the magnet. Remember, too, that these EC&M magnets are ALL-WELDED to keep pole shoes tight—to keep moisture out—to increase the efficiency of the magnetic circuit and to prolong magnet life.

write for bulletin 900

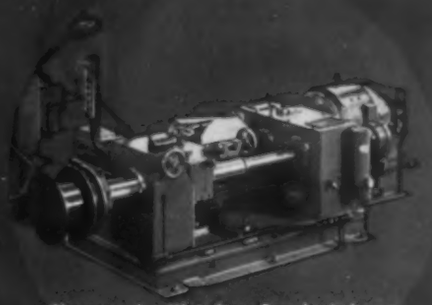
1762

SQUARE D COMPANY

EC & M DIVISION • CLEVELAND 28, OHIO

THIS WF WIRE FLATTENING TEAM

. . . SQUEEZES "DOWN-TIME", TOO



Close-up of a Waterbury Farrel winder at the delivery end of a WF Tandem Mill. Winder is provided with pneumatic clamping of reels. It has three adjustments for width of wire and width and positioning of drum or spool.

This complete Waterbury Farrel mill package includes 10" and 8½" Tandem Wire Flattening Mills, power driven double head Pay-off, Edger, Winder, footage counter, continuous thickness and width gauges and automatic electrical synchronizing control. Other WF tandems with up to five mills available.

Modern Waterbury Farrel Mill Design Insures High Production Plus Precision . . . Minimizes "Down-Time"

Here are some reasons why Waterbury Farrel Wire Flattening equipment can give you *more continuous,* high speed, precision production.

- Loading payoff and motor driven screwdowns for mills and edgers facilitate threading of wire with minimum effort and time.
- To protect precision operation, soluble oil is circulated internally and externally on the rolls and into coolant enclosures where wire is submerged. A refrigeration system maintains the coolant oil temperature at approximately 70° while a flotation unit keeps it clean and fresh. In addition, high speed mills also have a self-contained, automatically-filtered circulating mineral oil lubrication system for roll necks and drives.
- Transparent lucite covers at vital lubrication points such as gear cases and universal joints make it easy to check lubrication at a glance.
- Anti-friction bearings are used for all rotating members including the winder shaft. High precision anti-friction bearings are used on roll necks and edger arbors. This, combined with precision fitting of component parts enables WF mills to maintain tolerances well inside commercial allowance.
- Tungsten carbide ring rolls permit rolling the toughest alloys and increase roll life.
- Electric control keeps wire tension constant. Dancer rolls are used for fine wire.

Waterbury Farrel designs and builds a wide range of wire flattening mill equipment to suit specific requirements. Various sizes and combinations of single and multiple mill stands with auxiliary equipment are available for flattening ferrous and non-ferrous wire from the smallest diameters to 1" diameter and more. Speeds range up to and above 2500 FPM.

Write for further information.

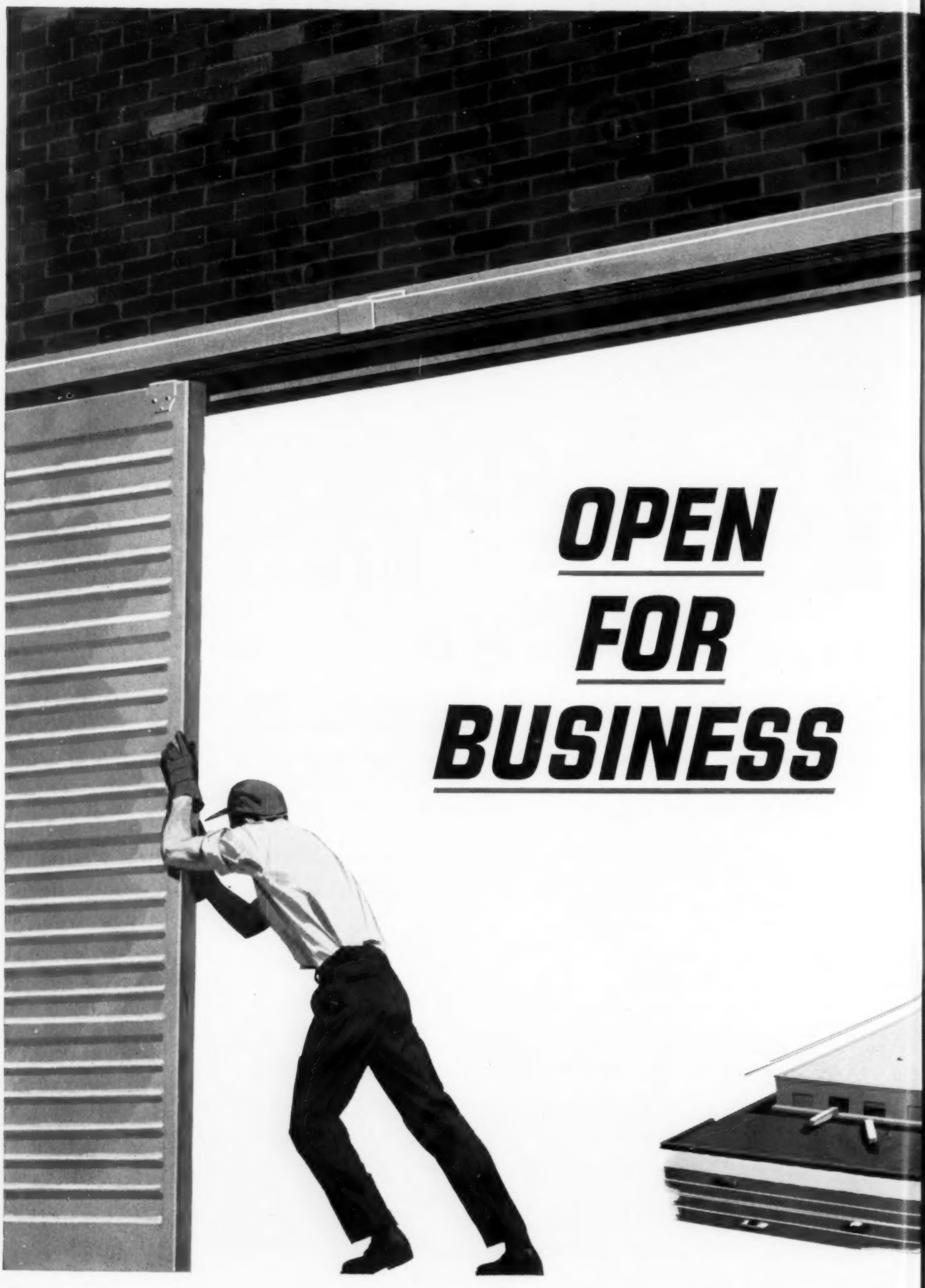
WATERBURY FARREL FOUNDRY & MACHINE CO.
WATERBURY 20, CONN.
Sales Offices: Chicago, Cleveland, Millburn, N. J.

WATERBURY FARREL FOUNDED 1851

A FEW OF THE MANY TYPES OF METAL WORKING MACHINERY MADE BY WATERBURY FARREL

MILL MACHINERY—Rolling Mills: Strip, Rod, Wire Flattening, (For Ferrous and Non Ferrous Metals) • Also Slitters • Straighteners • Cut-off Saws • Coilers • Winders, etc. *WIRE MILL EQUIPMENT*—Continuous Wire Drawing Machines (Upright Cone and Tandem) • Wire Flattening Mills • Chain Draw Benches • Pointers Swagers • Bull Blocks • String-up Machines • Spoolers, etc. *COLD PROCESS BOLT & NUT MACHINERY*—Headers (all types) • Rivet Machinery • Trimmers • Thread Rolling Machines • Slotters • Nut Formers and Tappers, etc. *POWER PRESSES*—Crank, Cam and Toggle; also Rack and Pinion Presses • Eyelet Machines Multiple Plunger Presses • Horizontal and Hydraulic Presses, etc.

WF 9


OPEN
FOR
BUSINESS

New refractories plant at Columbiana, Ohio, to give better-than-ever service to the steel industry!

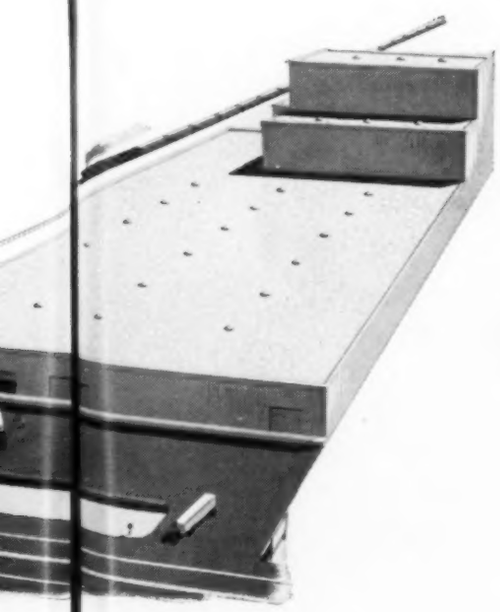
THE NEW Kaiser Chemicals refractory plant at Columbiana, Ohio has now begun production of steel furnace refractories.

Located on a 100 acre site adjacent to the main line of the Pennsylvania Railroad and the Ohio-Pennsylvania Turnpike, the new Columbiana plant assures rapid rail and truck transportation to steel producers in the Midwest and East.

Already serving the nation's steel industry from three plants in California, this new *Kaiser Chemicals* facility means new production to meet the increasingly heavy demand for Kaiser refractories. The new Columbiana plant will manufacture basic brick, mostly of the Periclase Chrome and Chrome Periclase types in addition to Permanente Ramming Mixes for refractory furnaces.

All these refractories are *especially designed* for peak performance in specific applications in open hearth and electric steel furnaces. In fact, for more than 12 years Kaiser Periclase Chrome and Chrome Periclase Brick have *set the standard* of performance for the industry. *That is why more and more steel producers regard them as the most dependable refractories available today!*

If you have a problem in your mill which might be solved by the *prompt delivery* of *superior quality, dependable refractories,* why not get in touch with us?



For more information call our nearest Sales Office: Kaiser Chemicals Division, 1924 Broadway, OAKLAND 12, Calif. . . . 3 Gateway Center, PITTSBURGH 22, Pa. . . . 518 Calumet Bldg., 5231 Hohman Avenue, HAMMOND, Indiana.

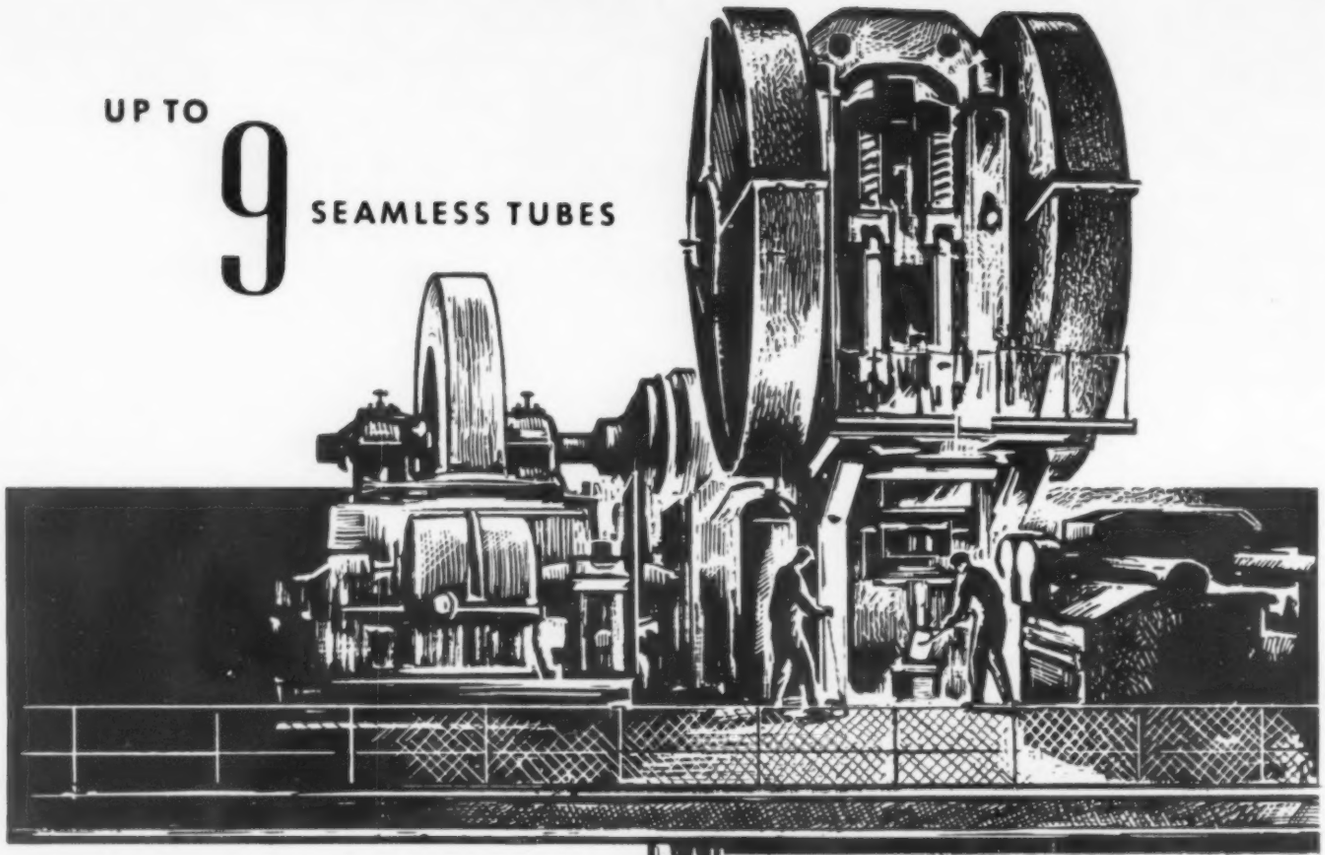
To obtain free copies of Kaiser Chemicals product literature write Kaiser Aluminum & Chemical Sales Inc., 1924 Broadway, OAKLAND 12, California, Dept. S6411.

Kaiser Chemicals

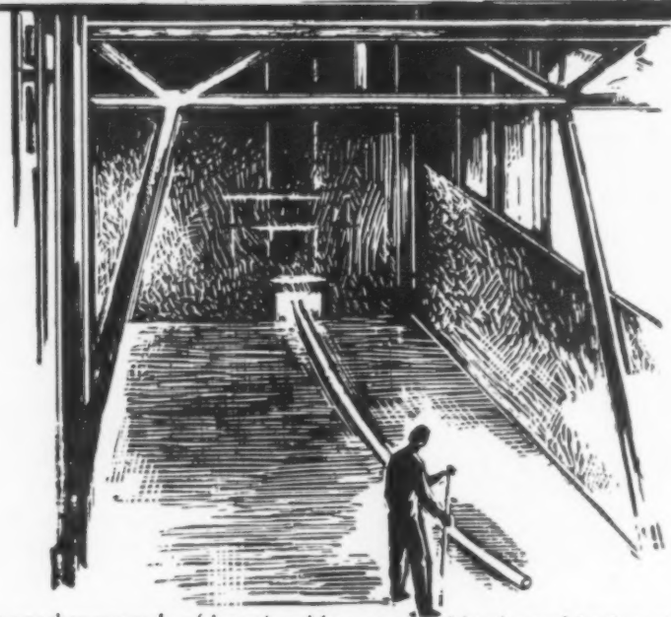
Pioneers in Modern Basic Refractories

Refractory Brick & Ramming Materials • Castables & Mortars • Magnesite
Periclase • Deadburned Dolomite

UP TO **9** SEAMLESS TUBES



per minute in standard lengths are made in one heat with our latest 1500-ton mechanical extrusion press in combination with an ordinary reducing mill. The extremely fast extrusion speed cuts operating and maintenance costs, increases tool life and permits the use of an inexpensive lubricant. Result: most flexible and lowest cost method for producing small diameter seamless tubes down to $^3/_8$" in practically all grades of steel and non-ferrous metals at high production rates. This Mannesmann-Meer mechanical extrusion press is an ideal supplement to existing seamless mills, where it is desired to increase total tonnage output by shifting present mill equipment over to larger sizes, and to use this press for producing small diameter tubing, at the same time widening the overall size range and versatility. Although our mechanical extrusion presses are in operation for over 25 years, continuous development is incorporated in today's press design to match present and future operating requirements.



This is another example of bringing Mannesmann-Meer's combination of

- CREATIVE ENGINEERING
- DESIGN EXPERIENCE
- OPERATING BACKGROUND
- AMERICAN MANUFACTURING SKILL

to bear on your tube mill problems.

MANNESMANN-MEER

ENGINEERING AND CONSTRUCTION COMPANY, 900 LINE STREET, EASTON, PENNA

WORLD SPECIALISTS IN HIGH-SPEED TUBE MILL MACHINERY

Wagner **ELECTRIC MOTORS... the choice of leaders in Industry**

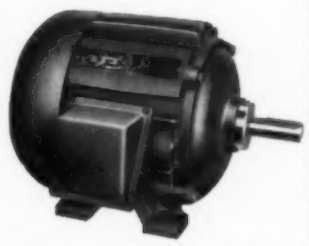
Wagner Protected Type Industrial Motors

lower your maintenance costs—cut down-time

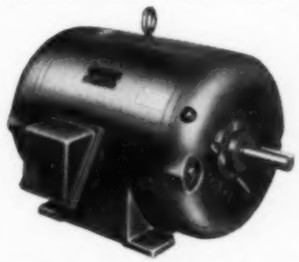
Wagner offers a complete line of protected type motors, specifically designed for use where severe conditions demand EXTRA protection—for bearings or windings... against corrosive vapors or abrasive dirt ...in explosive atmospheres or exposed outdoor locations.

In their specific applications, each of these Wagner Motors assures completely dependable performance—with a minimum of maintenance and a maximum of freedom from costly down-time due to motor failure. Openings are provided for relubrication to greatly prolong bearing life.

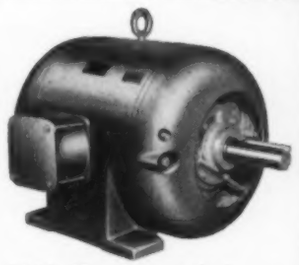
A Wagner engineer, expert on motor applications, will be glad to help you select the *right* motors for your specific needs. Just call the nearest of our 32 branch offices, or write for Wagner Industrial Motor Bulletins.



TYPE EP—Ribbed frame fan-cooled. New NEMA Frames. 1 to 30 hp.



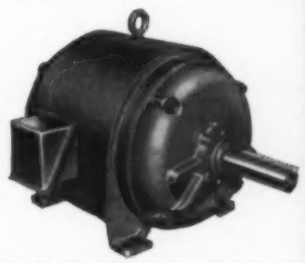
TYPE EP—Totally-enclosed fan-cooled. Corrosion-resistant frames. 40 to 250 hp.



TYPE JP—Fan-cooled . . . Explosion-proof. Cast iron frames. 40 to 250 hp.

TYPE DP—Drip-proof . . . corrosion-resistant. New NEMA Frames. 1 to 30 hp.

TYPE DP—Drip-proof. Cast iron frames. 40 to 125 hp.



TYPE RP—Open-type drip-proof. Welded steel frames. 125 to 500 hp.

WAGNER ELECTRIC CORPORATION
6483 Plymouth Ave., St. Louis 14, Mo., U. S. A.

M56-12

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS, AIR AND HYDRAULIC

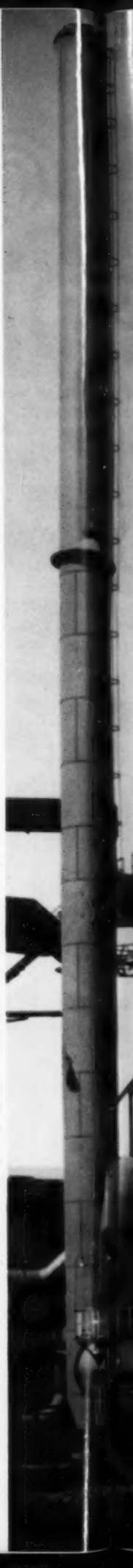
FREYN DESIGN®

Blast Furnace– The World's Largest!

Great Lakes Steel Corporation of Detroit, Michigan, a division of National Steel Corporation, operates this mammoth iron-maker. It was blown in during June, 1955, and is still the world's largest blast furnace.

The Freyn Department of Koppers Engineering and Construction Division designed and erected this giant. It has a hearth diameter of 30 feet, 3 inches, and a total interior volume of 64,435 cubic feet. Soaring 260 feet above yard level, this blast furnace weighs, when fully charged, about 12,800 tons.

KOPPERS COMPANY, INC., PITTSBURGH 19, PENNSYLVANIA
FREYN DEPARTMENT

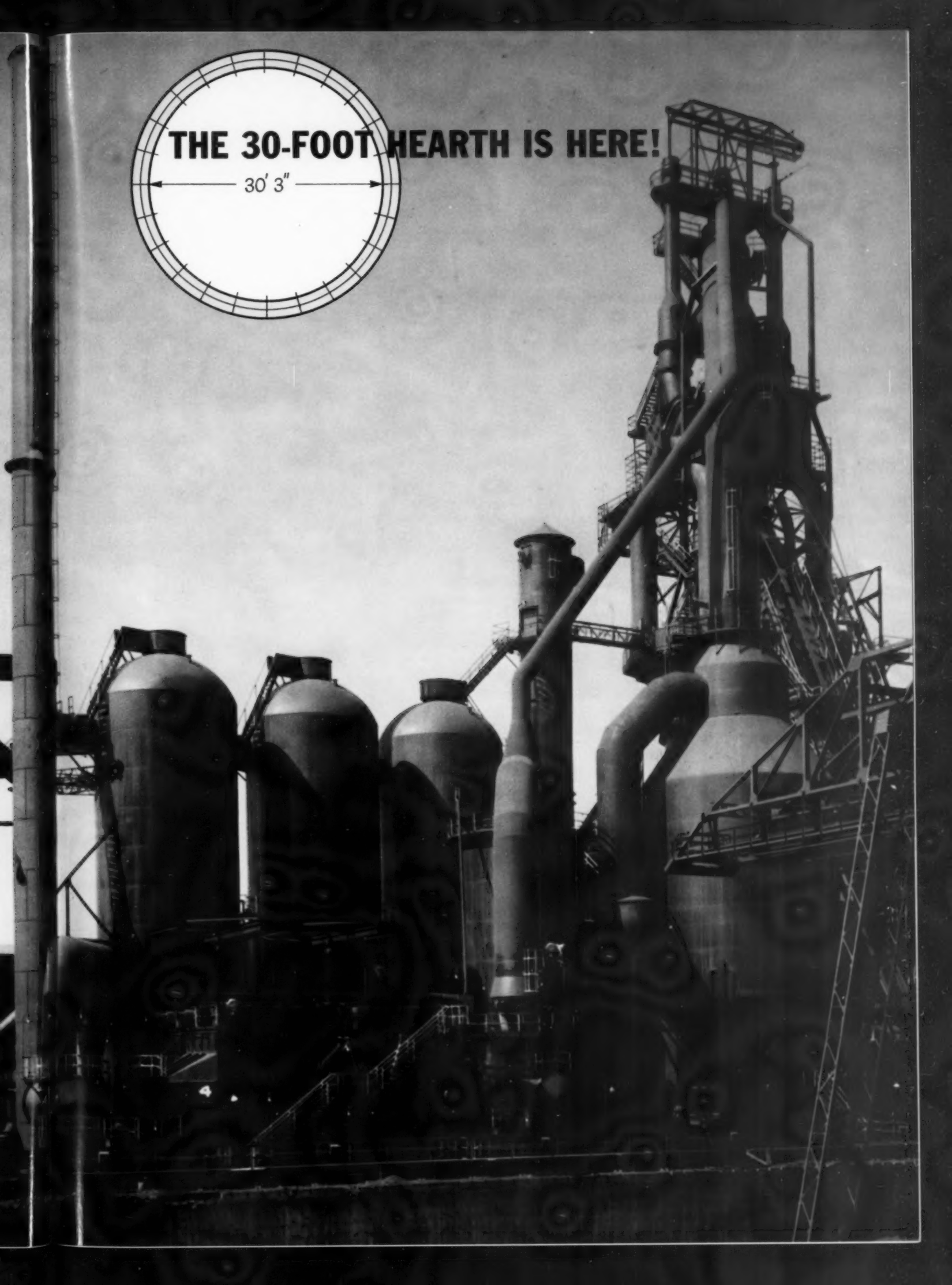


Great Lakes Steel's blast furnace at Zug Island, River Rouge, Michigan. With a hearth diameter of 30'3", this is the world's largest blast furnace.

Designing and constructing blast furnaces is just one way in which Koppers serves the steel industry. For any kind of metallurgical construction, you can count on Koppers. You are invited to consult with our Engineers and Management.

KOPPERS®

KOPPERS
ENGINEERING AND CONSTRUCTION


THE 30-FOOT HEARTH IS HERE!
30' 3"

Pumping Progress Report

FOR MECHANICAL ENGINEERS

An advertisement prepared by the Aldrich Pump Co., Member of Hydraulic Institute, U.S.A.

PUMP INSPECTION, MAINTENANCE AND REPAIR are jobs too frequently ignored in the design of production pumps. This has been verified by a survey of more than 15,000 pump installations. Speed and economy of maintenance was frequently quoted as a major factor in pump selection.

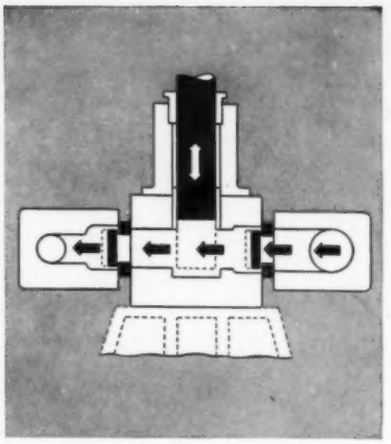
SECTIONALIZED FLUID-ENDS offer one of the best ways to guarantee both speed and economy in pump maintenance. As originated by ALDRICH Pump Co. Engineers, the Sectionalized Fluid-End comprises four main assemblies — the working barrel, suction manifold, discharge manifold and stuffing box.

SPEED IN MAINTENANCE is assured because of ease of accessibility of all wearing parts. Manifolds can be slid back on studs and valves removed as complete units. Split collar and flange connection of plunger to yoke permits easy removal of plunger.

ECONOMY OF MAINTENANCE results from speed in maintenance. Perhaps even more important is the simple fact that it is cheaper to replace a single section than a complete fluid-end. Another important economy is parts interchangeability. Among 3-, 5-, 7- and 9-plunger units of any series, wearing parts are interchangeable. Where a combination of multiplex pumps is required, this reduces spare parts stocks.

THE ALDRICH PUMP COMPANY is the originator of the DIRECT FLOW principle — a design innovation that utilizes the sectionalized fluid-end principle. Aldrich Engineers have become known as the people to take your tough pumping problems to. We have never turned down a challenge.

FURTHER INFORMATION can be had direct from the company. Tell us your problem and we'll send you Data Sheets describing the size pump we recommend to solve your problem. Address your request to: The Aldrich Pump Company, 21 Pine Street, Allentown, Pa.



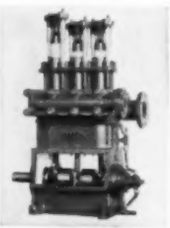
Aldrich Direct Flow Fluid-End Design

...for your tough pumping problems specify ALDRICH

The Direct Flow principle, an Aldrich design innovation, is a major forward step toward the solution of tough pumping problems of all kinds. Not only does it eliminate two right-angle turns in the fluid-end, but in addition makes possible complete Fluid-End Sectionalization. This is another Aldrich design innovation which permits economies of maintenance and repair offered by no other type pump.

CHECK THESE ADVANTAGES OF SECTIONALIZED FLUID-ENDS:

Less expensive parts replacement
Ease of inspection and maintenance
Interchangeable wearing parts
No special equipment for valve removal
Easily accessible stuffing boxes



Write today for Data Sheets describing the Direct Flow Pump Series.

THE ALDRICH PUMP COMPANY

Originators of the Direct Flow Pump
21 PINE STREET
ALLENTOWN, PA.

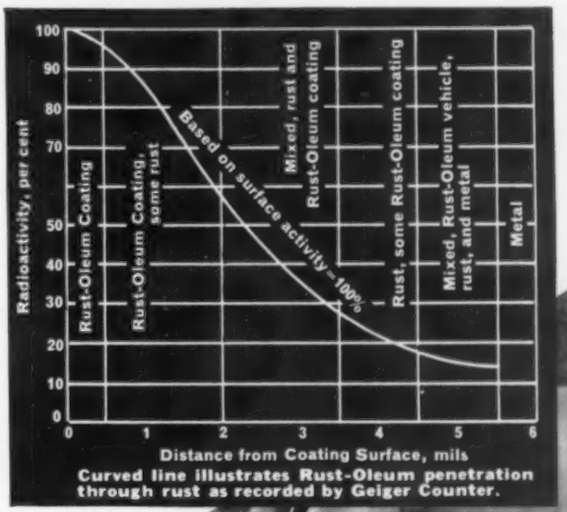
Representatives in principal cities

RUST-OLEUM®

PENETRATION

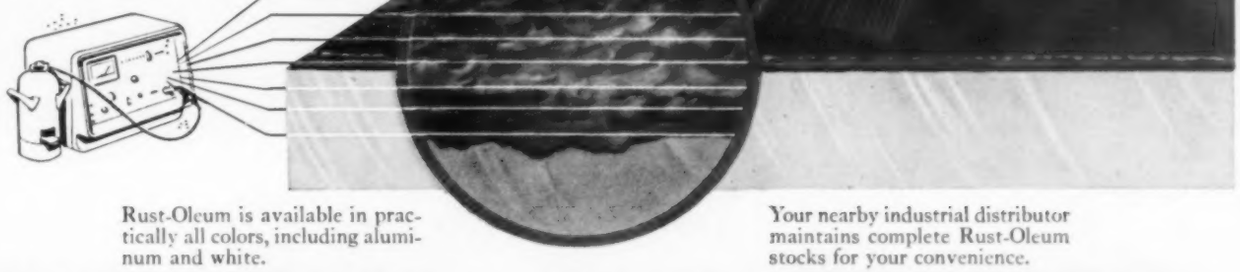
through rust to bare metal traced by Geiger Counter. To effectively stop rust—the vehicle of a protective coating, when applied over a sound, rusted surface—must penetrate through the rust down to bare metal. **Rust-Oleum does exactly that!—as proved by radioactive research!** Rust-Oleum's specially-processed fish oil vehicle was radio-activated and formulated into Rust-Oleum 769 Damp-Proof Red Primer—then applied to rusted test panels. Penetration *through rust* to bare metal by Rust-Oleum's specially-processed fish oil vehicle was then traced by Geiger Counter.

You stop rust, because Rust-Oleum's fish oil vehicle soaks deep down to bare metal and into the tiny pits where it drives out air and moisture that cause rust. You save, because this same *penetration* enables you to apply Rust-Oleum directly over rusted surfaces—usually eliminating costly surface preparations. Attach coupon to your letterhead for your thirty-page report entitled, "The Development of a Method To Determine The Degree of Penetration of a Rust-Oleum Fish-Oil-Based Coating Into Rust On Steel Specimens," prepared by Battelle Memorial Institute technologists.



Curved line illustrates Rust-Oleum penetration through rust as recorded by Geiger Counter.

There is only one Rust-Oleum. It is distinctive as your own fingerprint. Accept no substitute. Buy—and specify only Rust-Oleum. You'll be happy that you did.



Rust-Oleum is available in practically all colors, including aluminum and white.

Your nearby industrial distributor maintains complete Rust-Oleum stocks for your convenience.

RUST-OLEUM®

STOPS RUST!

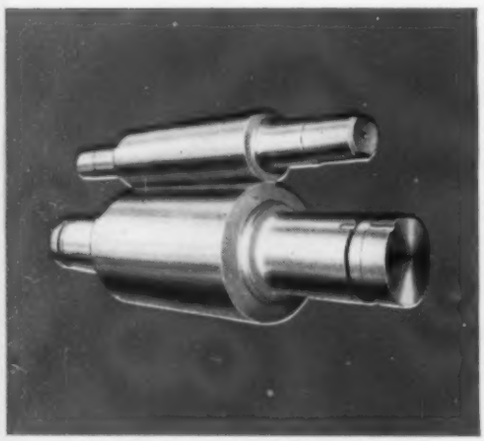
See our Catalog in Sweets, or write for complete information.

ATTACH TO YOUR LETTERHEAD—MAIL TODAY

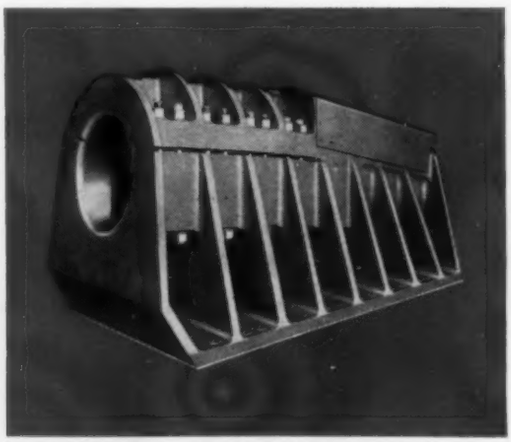
Rust-Oleum Corporation
2445 Oakton Street
Evanston, Illinois

- ☐ Complete literature including color charts.
- ☐ Thirty-page report on Rust-Oleum penetration.
- ☐ Nearest source of supply.

CONTINENTAL 26" x 49" x 66", 4-high reversing hot strip mill in the Newport Steel Corporation Plant, Newport, Kentucky.

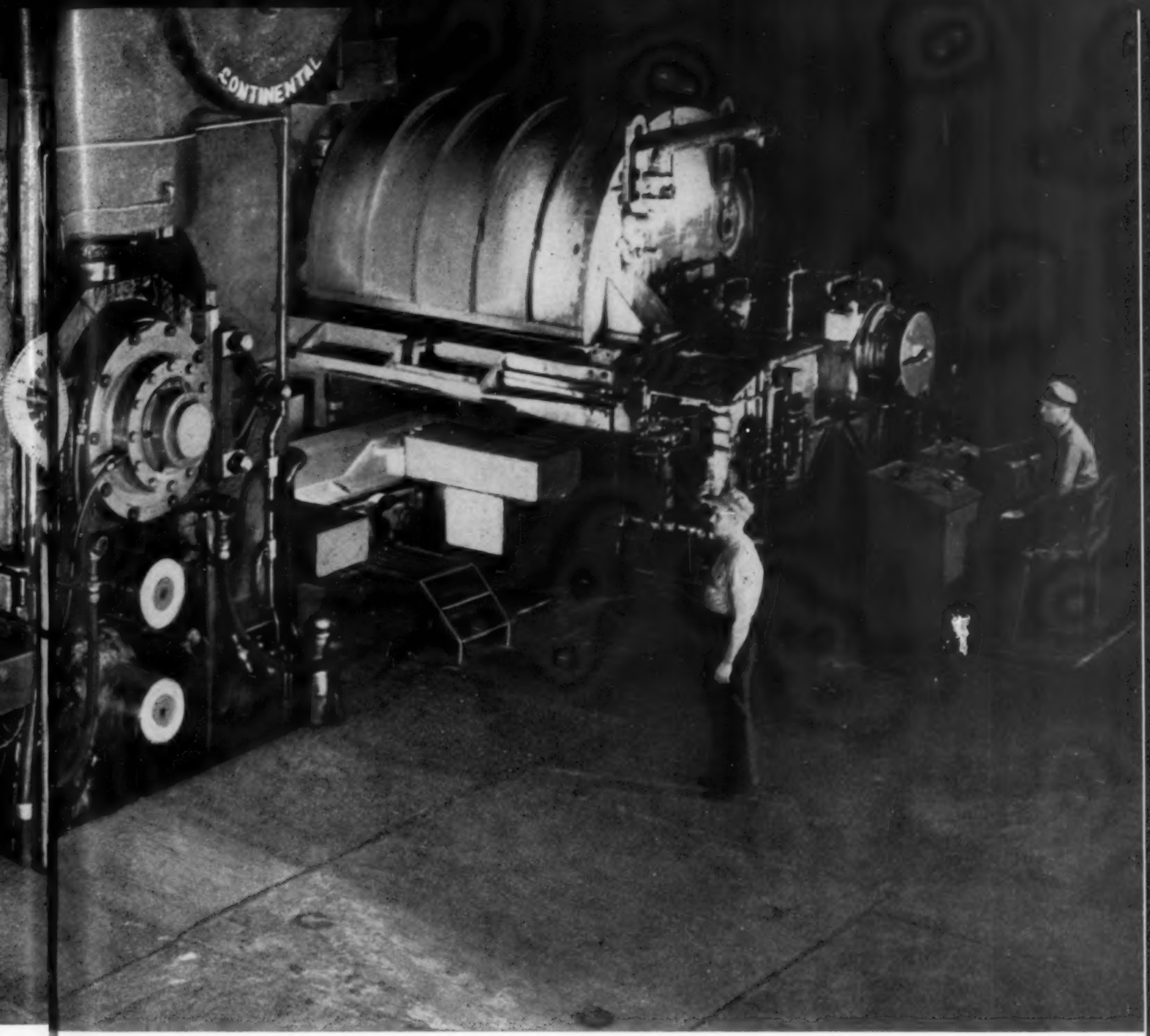


ROLLS—iron, alloy iron and steel rolls for all types of rolling mills.



CASTINGS—carbon and alloy steel castings from 20 to 250,000 pounds.

WELDMENTS—fabricated steel plate, or cast-weld design.



BLAW-KNOX makes what it takes

to roll precision-gage hot strip directly from ingots

Precision-gage hot strip is rolled directly from ingots by this modern CONTINENTAL 66-inch 4-high reversing hot strip mill in the Newport Steel Plant at Newport, Kentucky.

A full range of gages and analyses, including carbon and special grades of steel, are rolled by this 26″ x 49″ x 66″ mill. The mill was designed to incorporate an existing 4000 hp. d.c. reversing motor through a pinion stand.

Blaw-Knox designs and builds *complete* rolling mill installations—assumes undivided responsibility from preliminary engineering to satisfactory operation. At any time we'll be glad to discuss your plans with you.

BLAW-KNOX COMPANY
Foundry and Mill Machinery Division
Blaw-Knox Building • 300 Sixth Avenue
Pittsburgh 22, Pennsylvania

Complete Rolling Mill Installations . . . including all auxiliary equipment . . . for ferrous and non-ferrous metals

Hot strip mills • cold strip mills • slabbing mills • temper mills • universal mills • plate mills • blooming mills • structural mills • rail mills • billet mills • rod mills • merchant mills • roll lathes • chippers • special machinery • and complete auxiliary equipment.

50th Anniversary
BLAW-KNOX
1906-1956

CONTINENTAL
Foundry & Machine

V. R. BROWNING
MILL TYPE CRANES
TO Specification
Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.

BOX 309, WILLOUGHBY (CLEVELAND), OHIO

Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

New mill on TIMKEN® bearings tapers 10′ x 33′ aluminum sheets for aircraft wings

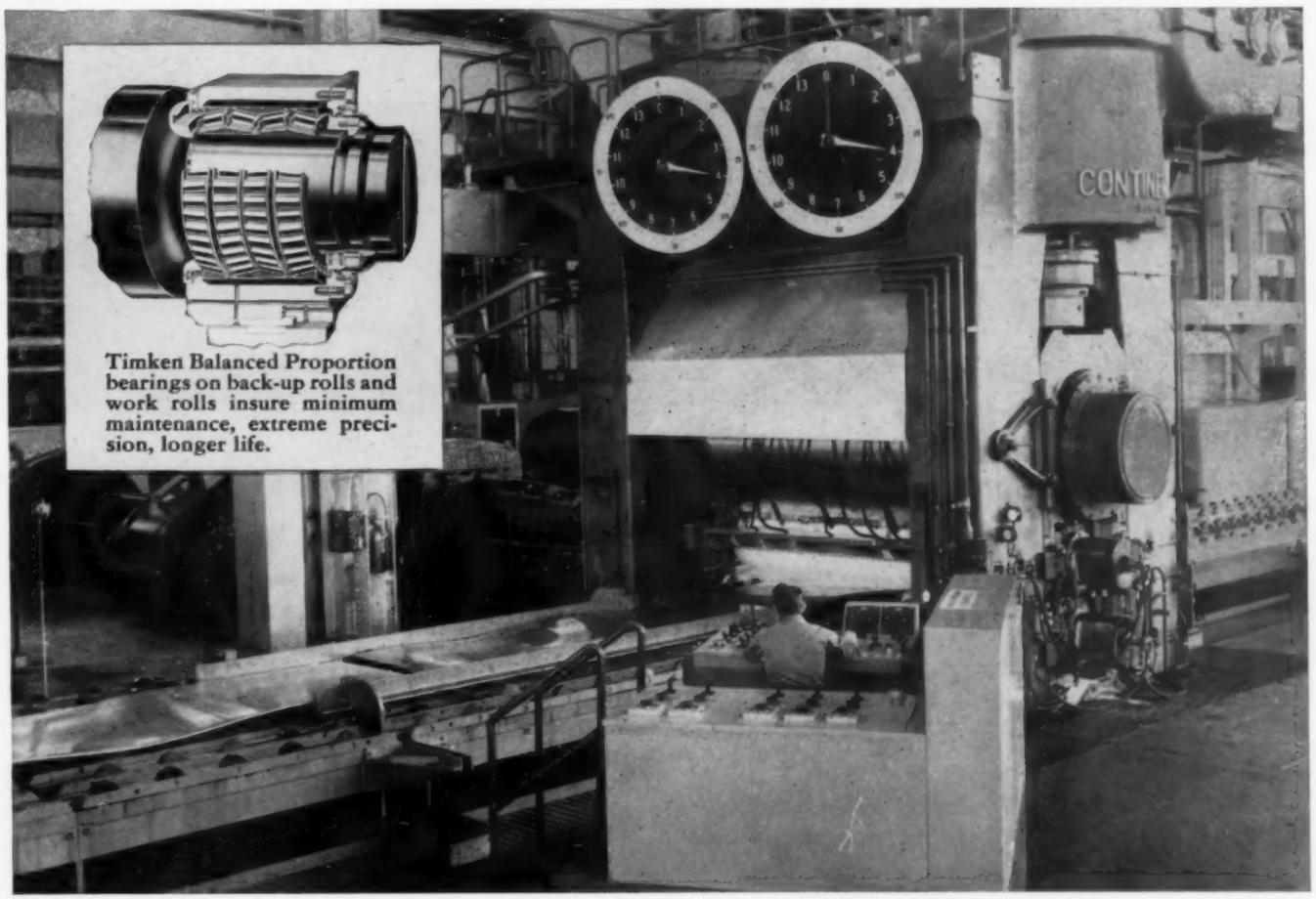
A 4-HIGH reversing mill, 32″ x 60″ x 144″, which tapers aluminum sheet and plate up to 10′ wide and 33′ long, is now in operation. This mill is used for the fabrication of tapered sheet and plate. Tapered sheet and plate products permit the fabrication of modern aircraft of increased speed and increased carrying capacity at no sacrifice in strength. Built by the Continental Foundry & Machine Division of Blaw-Knox Company, this huge new rolling mill uses Timken® tapered roller bearings on back-up rolls, work rolls, screw-downs and breaker blocks.

Timken balanced proportion bearings give this mill the extreme precision required in such rolling operations. Timken balanced proportion bearings have load ratings up to 40% higher than the same-size bearings in older designs. In some mills, they increase bearing life expectancy almost three times. And the mill can be stopped and restarted without altering or relieving screwdown pressures.

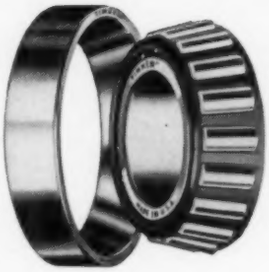
Timken bearings, because they're tapered, take both radial and thrust loads in any combination. They practically eliminate friction because they're designed by geometrical law to have true rolling motion. And made with extreme accuracy to conform to their design.

Always specify Timken bearings in the equipment you build or buy. Look for the trade-mark "Timken" stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



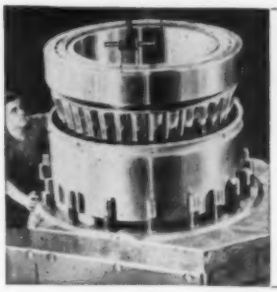
Timken Balanced Proportion bearings on back-up rolls and work rolls insure minimum maintenance, extreme precision, longer life.



TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

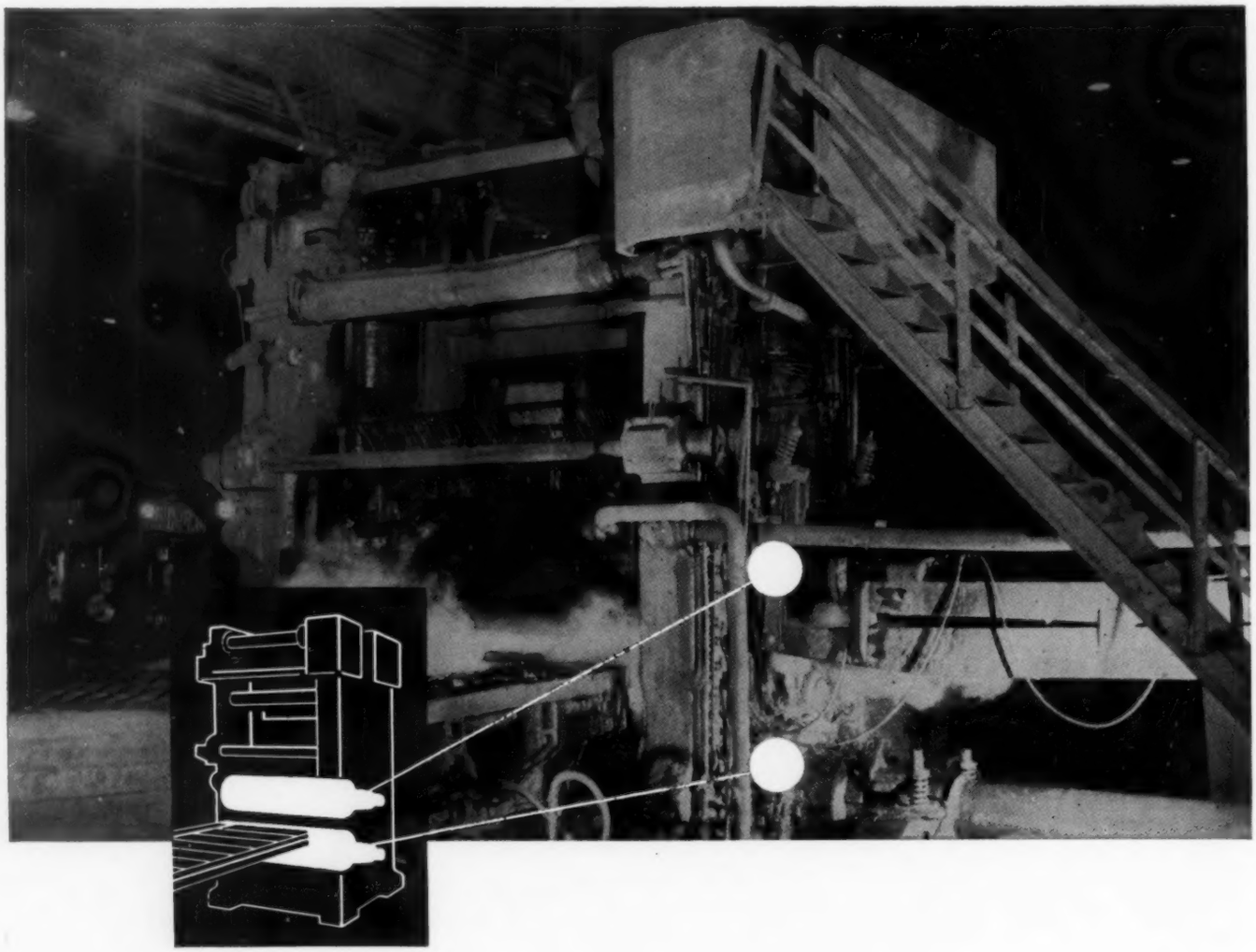


ROLL NECK BEARING ENGINEERING SERVICE

Our field and service engineers have had years of experience with problems of roll neck bearing design and operation. They'll help you select bearings and design mountings. Only Timken tapered roller bearings have these advantages: 1. advanced design; 2. precision manufacture; 3. rigid quality control; 4. Timken fine alloy steels.

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ↕ AND THRUST →◫← LOADS OR ANY COMBINATION ✳

Lubricating roll necks is no easy job



Lubricating the roll necks of a steel mill calls for a lubricant that will resist high temperatures. The lubricant must also function in the presence of steam, water, mill scale and other abrasive materials. It has to cushion great shock loads and cling tenaciously to the bearings it protects. It must last a long time . . . and it must be economical in use.

Atlantic Lubricant 10 performs exceptionally well in this service. It is being used in a pressure system on the mill illustrated, at the Lukens Steel Company in Coatesville, Pa., for the lubrication of roll neck bearings, pinion and spindle bearings.

Selecting the correct lubricant for the job is simplified when you call in your Atlantic Lubrication Engineer. He is a man with years of on-the-job knowledge of heavy industrial lubrication requirements of all kinds.

Why not see for yourself the value of Atlantic service? Just write, wire or phone the office nearest you for full information. The Atlantic Refining Company, Dept. V-8, 260 South Broad Street, Philadelphia 1, Pa.

PROVIDENCE, R. I.
430 Hospital Trust Bldg.

SYRACUSE, N. Y.
Salina and Genesee Sts.

READING, PA.
First and Penn Aves.

PITTSBURGH, PA.
Chamber of Commerce Bldg.

ATLANTIC

LUBRICANTS · WAXES
PROCESS PRODUCTS

TAKES LESS SPACE THAN PICKLING AT EMPIRE STEEL

descales carbon strip at 250′ per minute; slashes acid tank requirements 75 %

A 16-wheel Wheelabrator mechanical descaling machine at Empire Steel Corporation in Mansfield, Ohio, cleans 250′ of carbon strip a minute and has eliminated all pickling except a 13-second immersion in a tank only 60′ long. The Wheelabrator is 66′ long and does cleaning that would require 250′ of tanks for straight pickling. This eliminates 75% of acid requirements and reduces acid disposal problems and tank maintenance. In addition, the matte finish imparted by Wheelabrating enhances the cold working properties of the metal. The high cleaning capacity of Wheelabrator equipment in a relatively small area means savings in floor space for new lines and permits increase in capacity of existing lines in the floor space presently available.

For more information on Wheelabrator blast descaling principles and savings, send today for Bulletin 864.

WHEELABRATOR
CORPORATION
(Formerly American Wheelabrator & Equipment Corp.)
396 S. Byrkit St., Mishawaka, Indiana

World's Largest Builders of Airless Blast Equipment

" . . . and this was accomplished without disrupting other work going on in area . . . and, more important, without an accident!"

Early last year, management of a large steel plant decided that its 90" Blooming Mill had to be replaced. Production requirements demanded that the down-time for making the extensive changes . . . including a complete tear-out of the old foundation . . . had to be held to a minimum.

It was at this point that CHICAGO CONCRETE BREAKING COMPANY was called in for consultation. Realizing the vital importance of every hour to the plant, CHICAGO CONCRETE'S skilled blasting experts used a three-dimensional model of the foundations to lay out the drilling pattern. As a result of this careful planning, 95% of the drilling was accomplished PRIOR TO SHUT-DOWN OF THE MILL AND WITHOUT ANY INTERFERENCE WITH PRODUCTION.

Thus, blasting was performed simultaneously with the removal of the mill. Using modern methods, developed over 35 years of experience, CHICAGO CONCRETE was able to control-blast and remove 5,200 cubic yards of concrete and slag SOME 60 DAYS AHEAD OF THE TIME NORMALLY TAKEN BY OLD-FASHIONED METHODS. Needless to say, reconstruction was able to begin well ahead of schedule.

With careful planning, intelligent preliminary work, and skill . . . born of experience and developed over three decades . . the job was completed in minimum time, ahead of schedule, and without an accident. This is but another example of the service available to you by CHICAGO CONCRETE BREAKING COMPANY . . .

AND NOW

CHICAGO CONCRETE CONSTRUCTION COMPANY offers a complete industrial construction service . . . handling anything from minor masonry, steel or foundation repairs to complete furnace rebuilds.

CHICAGO CONCRETE BREAKING CO.

EDWARD GRAY, PRESIDENT

12233 S. AVENUE "O", Chicago 33, Ill., BAyport 1-8400 PITTSBURGH AREA - 213 Corey Ave., Braddock, Pa., Electric 1-1656

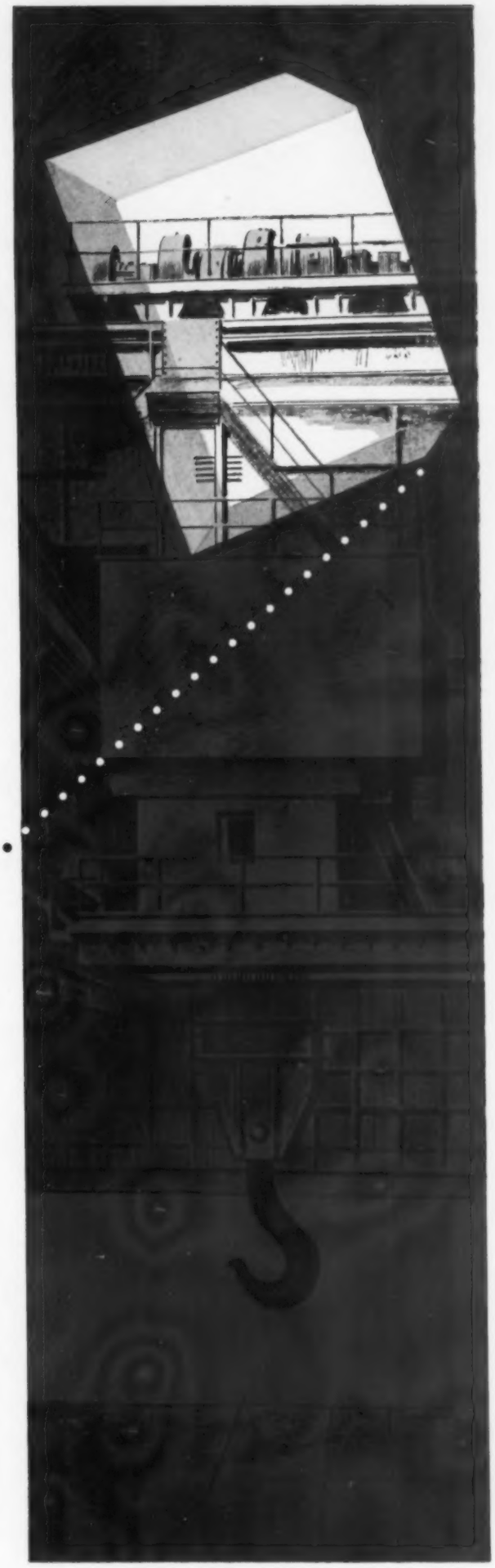
SERVING THE PRIMARY METALS AND OIL INDUSTRIES WITH KNOW HOW, EQUIPMENT AND MANPOWER FOR 35 YEARS

Why NATIONAL TRADE-MARK *brushes are best for*

CRANE AND HOIST MOTORS

Each Brush in the complete line of "National" brushes is compounded to meet a specific set of operating conditions. Together, these service-proved "National" brush grades provide a proper choice for every application in your mill or mine.

For Example, the following "National" brushes are recommended for crane and hoist service, as indicated. They are the finest brushes money can buy . . . so much the best for these services that you will find they actually save you money in over-all cost of operation.



GRADES AX-5, TA-35, TA-45 and 401

These are standard grades with long service-records; application is in accordance with machine design.

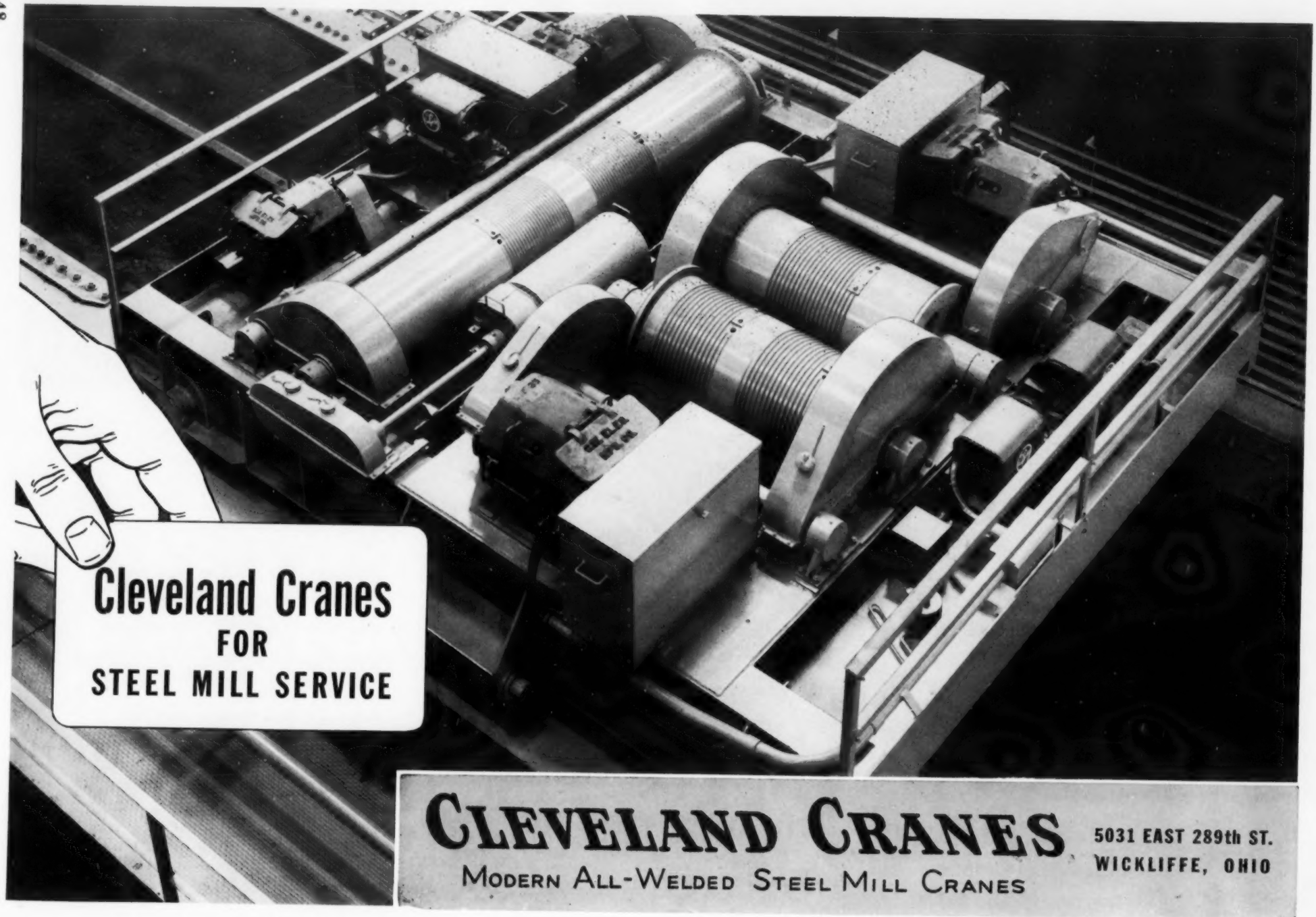
GRADES 850 and N-4

Grade N-4 is highly efficient in handling alternate extremes of light and heavy loading; grade 850, for open-hearth ladle, soaking pit cranes and severe hoist conditions.

Be Certain of your brush selections. Get the recommendations of a "National" brush specialist to assure top performance and long life of costly equipment.

The term "National", the Three Pyramids Device and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.
SALES OFFICES: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco
IN CANADA: Union Carbide Canada Limited, Toronto


Cleveland Cranes
FOR
STEEL MILL SERVICE
CLEVELAND CRANES
MODERN ALL-WELDED STEEL MILL CRANES
5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops and Shorts

SETTLEMENT of the steel strike gave the union a really nice three-year package with which it can well be happy: a 7.5 cent hourly increase now and 7 cents more in each of the next two years, plus increased increments between job classifications and increased shift differentials; cost of living adjustment; Sunday premium pay; higher premium pay for holidays; another paid holiday; jury duty pay; supplementary unemployment benefits; improved insurance, pension and vacation plans; and a union shop. The steel companies estimate the first-year cost at 20.7 cents per hour, and the second and third years at about 16 cents each.

This is doubtlessly a better deal than would have been obtained had not pressure to settle come out of Washington. It certainly gives increases not justified by productivity, and thus contributes to further inflation.

▲

IN the past, inflation has stemmed from the creation of artificial money or from unsound credit policies by central or government banks. Now, a third source has appeared in the power of large unions to force up wage rates in excess of productivity increases — and here is a real threat to our economy.

As business and industry grew into gigantic corporations, government regulation became necessary to protect the public from unscrupulous exploitation and to safeguard the national economy. Just as surely, and for the same reasons, unions must be regulated as they grow into giant monopolies — and the time is not far off.

▲

A matter already ripe for regulation is that of compulsory union membership, which is unquestionably undemocratic and an infringement on individual freedom.

Liberty is something that we all hold to be precious. But the various ideas of liberty are indeed strange to behold. Actually, true liberty for all can exist only when each individual's liberty does not encroach on another individual's liberty.

Yet we have the union leaders, who fought so strenuously for the right of workers to join a union, now rabidly insisting that a man should be forced to join a union in order to work, regardless of the man's own preference.

It is only too apparent that union leaders fear the necessity of holding their members and getting new ones on the basis of meriting support, as is necessary when membership is a voluntary matter.

OUR Detroit spy says that seat belts are proving to be unnecessary in the more expensive automobiles. The payments keep you strapped.

▲

AS if to usher in the strike with a bang, the steel industry set tonnage records in June: 9,758,000 tons of steel for the month and 62,644,175 tons for the half year. And at the end of June, the industry had produced more than one billion tons of ingots since the end of World War II.

▲

A wise correspondent tells us he has quit trying to understand women and is just enjoying having them around.

▲

ACCORDING to the American Iron and Steel Institute, the steel industry used a record 743,000 tons of metallic manganese during 1955. Principal sources included India, the Gold Coast of Africa, Cuba, Union of South Africa, Brazil and the Belgian Congo.

▲

THE Wall Street Journal observes that if men behaved after marriage as they do during their engagements, there wouldn't be half as many divorces — but there would be twice as many bankruptcies.

▲

TELEVISION cameras are being made as small as two inches in diameter by six inches long, to be used to spot faults inside tubes or similar constructed spots.

▲

IN case you're interested, August is National Sandwich Month.

▲

SCIENTISTS say we're taller in the morning than we are in the evening. Maybe so, but most people are shortest around the end of the month.

▲

THE National Association of Manufacturers has proposed the following code of conduct for better labor-management relations in the public interest:

1. A recognition of the right of every individual to join a union or to refrain from joining, as he chooses.
2. No interference with this right through violence, retaliation, subterfuge or coercion of any sort.
3. A striving for the utmost efficiency and productivity and the elimination of economic waste of every type.
4. An end to monopoly, whether on the part of organized labor or industry.
5. Keep politics out of labor-management relations; and avoid trying to obtain by political pressures that which cannot be justified economically.

INSULATING FIRE BRICK	Temp. Limit	Density (lb./cu ft)	Strength (cold crushing, psi)	Conductivity (Btu in. sq ft F hr at 1000F mean temp)
JM-3000	3000F*	64	400	3.20
JM-28	2800F*	58	150	2.50
JM-26	2600F*	48	190	2.22
JM-23	2300F*	42	170	1.91
JM-20	2000F*	35	115	1.22
JM-1620	1600F* / 2000F**	29	70	1.02
Sil-O-Cel Super	2500F**	40	300	1.95
Sil-O-Cel C-22	2000F**	38	700	1.88
Sil-O-Cel 16L	1600F*	34	350	1.07

*Back-up or exposed
**Back-up only

From Johns-Manville refractory research...

insulating fire brick with balanced properties for unsurpassed heat-control effectiveness

The nine types of insulating fire brick produced by Johns-Manville offer furnace builders and operators a common advantage—*balanced properties!*

The Johns-Manville insulating brick formulated for your service gives you the ideal combination of physical and thermal properties without sacrificing one for the other. This means you get unsurpassed heat-control effectiveness . . . greater economy in furnace design . . . hours saved in reaching operating temperatures!

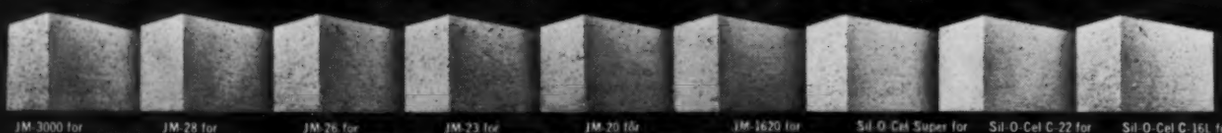
For a good example of the value of *balanced properties*, take the proved performance of JM-3000 insulating fire brick. Formulated for 3000F temperature service, this insulating fire brick has unusual load bearing strength, high spall resistance, low shrinkage and thermal conductivity proportionate to its density.

Johns-Manville has two strategically located plants for the production of insulating brick: Lompoc, California and Zelienople, Pennsylvania. Insulating brick are available from the stocks of authorized J-M distributors in key industrial areas.

For complete information, call your nearest J-M representative. Or write for brochure IN-115A to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

Johns-Manville REFRACTORY AND INSULATING REFRACTORY PRODUCTS

THE INDUSTRY'S MOST COMPLETE LINE OF INSULATING FIRE BRICK



JM-3000 for temperatures to 3000F | JM-28 for temperatures to 2800F | JM-26 for temperatures to 2600F | JM-23 for temperatures to 2300F | JM-20 for temperatures to 2000F | JM-1620 for temperatures to 1600F exposed; to 2000F back-up | Sil-O-Cel Super for temperatures to 2500F, back-up | Sil-O-Cel C-22 for temperatures to 2000F, back-up | Sil-O-Cel C-16L for temperatures to 1600F, back-up or exposed

NEW

"BUFFALO" TYPE "CR" RADIAL BLADE FAN

Engineered for Your High-Volume High-Pressure Jobs

Newest in the complete line of "Buffalo" Fans, the Type "CR" offers high mechanical efficiency (above 78%) over a broad range, and has high-pressure, high-volume characteristics that make lower first cost possible on many applications. It is also highly suitable for handling dust-laden air efficiently.

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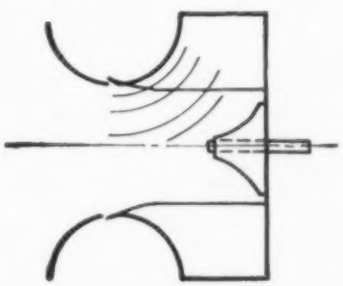

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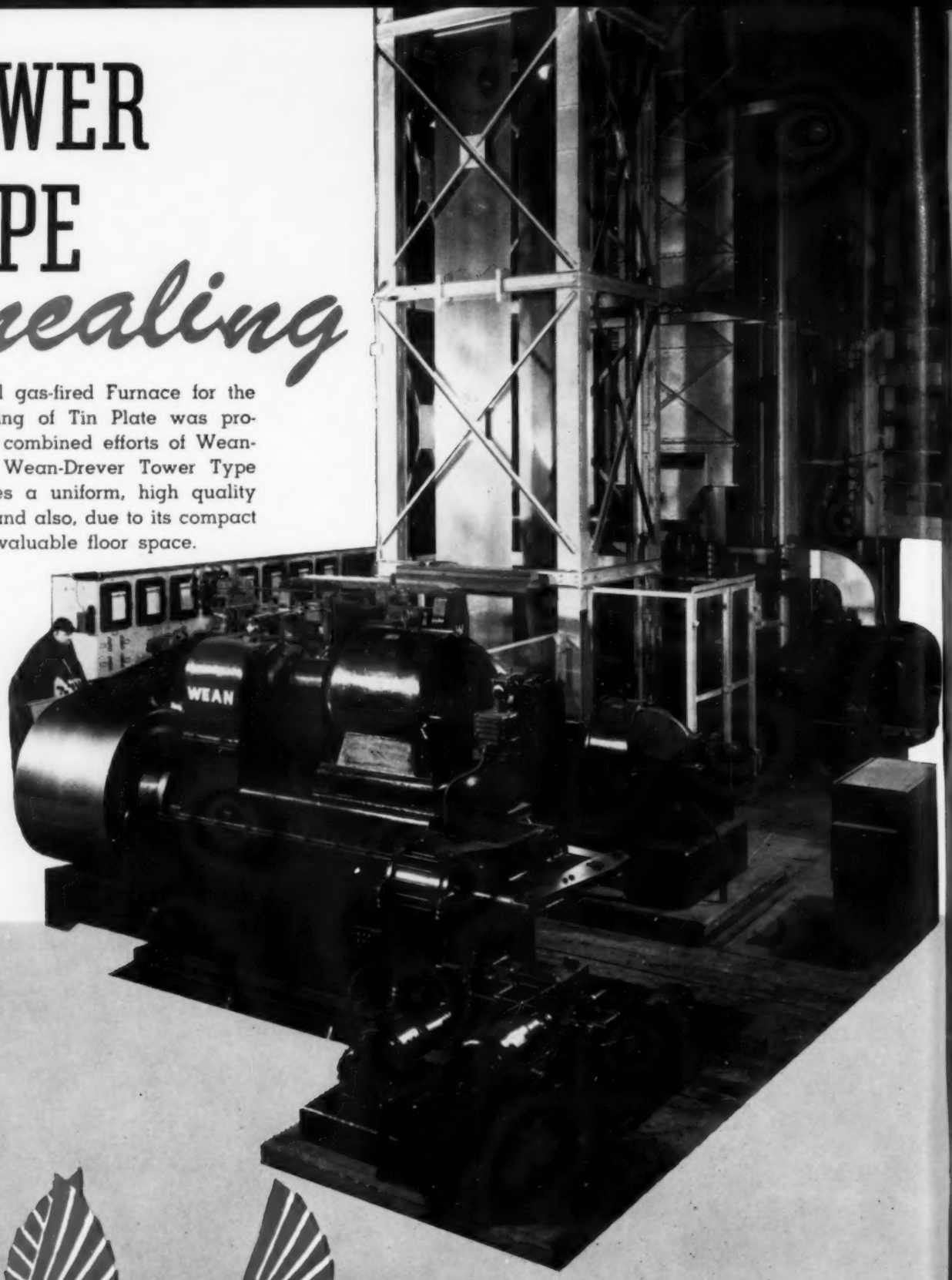

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Iron AND Steel ENGINEER

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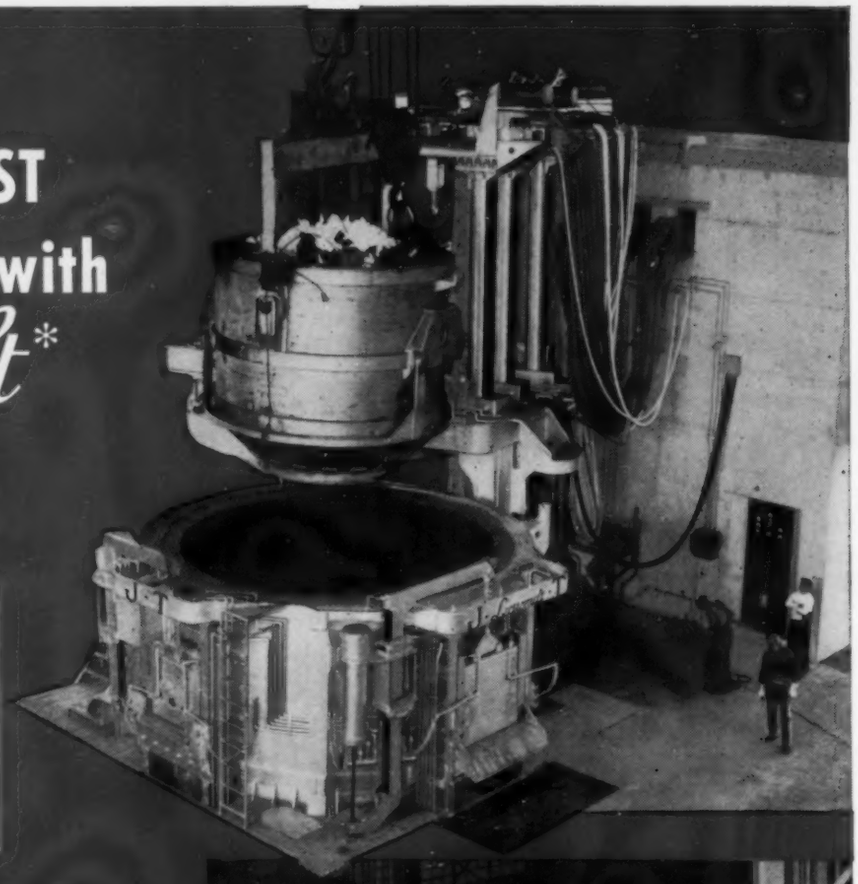

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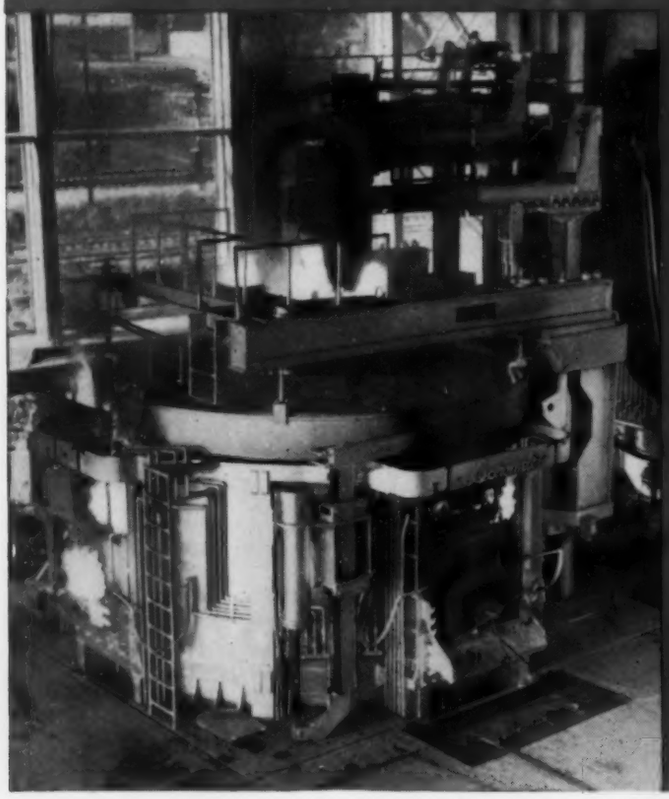

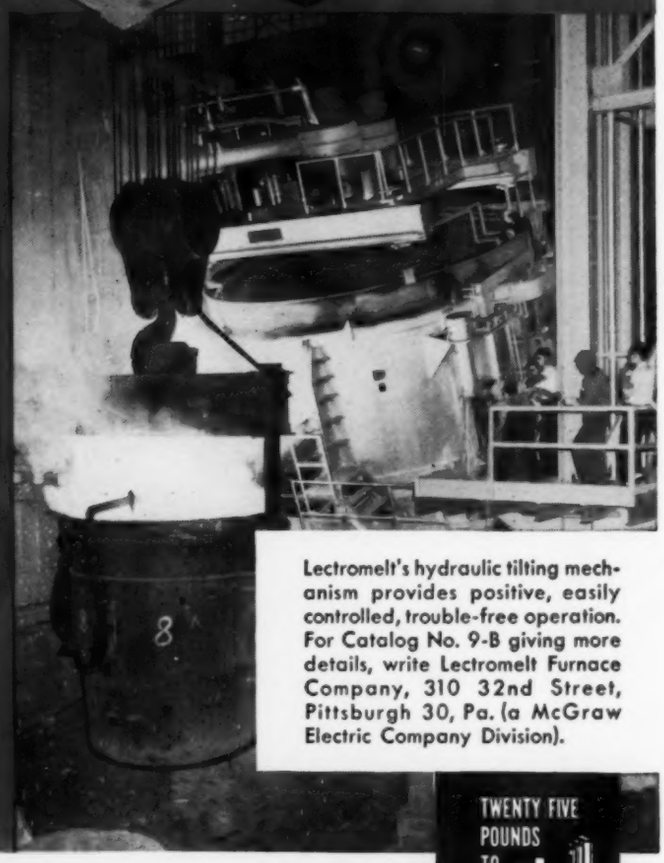

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Expansion at Bethlehem's Saucon Division

The expansion of Bethlehem's Saucon division will be an important factor in helping supply demand for structural sections . . . . fitting the additional facilities economically in the present plant required the solution of many engineering problems . . . .

ENGINEERING

By J. A. BELL
Chief Engineer
Bethlehem Steel Co.
Bethlehem, Pa.

▲ THIS paper covers the engineering, construction, and operation of the expansion at the Saucon Division of the Bethlehem Steel Company's plant at Bethlehem, Pa. The plant at Bethlehem is divided into three divisions, Lehigh division, Saucon division, and coke oven division. The expansion program covered concerns only the Saucon division, which produces Bethlehem structural shapes and occupies an area of approximately 270 acres.

This division, construction of which first got underway in 1906, was designed and built to roll standard structural shapes, wide-flange sections, I-beams, channels, angles, and rails. Numerous minor changes have taken place in this division over the past 45 years. Some units have been added and others eliminated entirely, but this was the first major improvement program since the original Saucon division was built.

At the time the new expansion program was concieved in 1953, the following units were in operation:

40-in. blooming mill No. 1, 28-in. structural mill, 40-in. blooming mill No. 2, 42-in. shape mill, 46-in. blooming mill, 48-in. shape mill, 12 and 18-in. finishing mills, fabricating shops, hot saws, cold saws, shears, transfer beds, cambering, beam slitting, straightening equipment plus the usual run of furnaces and mill tables.

The geographical location of this division makes it extremely difficult to expand it in any one of the four directions. Figure 1 shows a view of the division. It is bounded on the north by the Lehigh Valley Railroad and Lehigh river; on the east by low level trackage and public highway; on the south by city property, and on the west by our Lehigh division.

Therefore, any new equipment must of necessity be laid out to take advantage of available space between present buildings, even though that might require unconventional designs for both buildings and structures.

With the rolling of structural shapes, it stands to reason that a continuous flow of product in one direction is preferred, eliminating as much back-tracking as possible, but the Saucon division does not lend itself 100 per cent to this favorable type of operation due to the congested area surrounding the mills.

There have been very few major changes in the layout of this division throughout the years, with the exception of the usual additions here and there to obtain better operation.

However, no major additions or alterations were made that would classify these mills as being modern and up-to-date.

Other than the 12 and 18-in. mills, all the larger mills are still driven by steam engines.

The following are the major new items that were planned for this expansion program:

1. Soaking pit furnaces.
2. 32-in. Blooming mill.
3. 40-in. Blooming mill.
4. 500-ton Bloom shear.
5. 28-in. Mill furnaces.
6. 48-in. Mill hot bed.
7. 42-in. Mill hot bed.
8. Auxiliary shipping yard.
9. Rotary straightener for beams.
10. Rotary straightener for Tee bars.
11. Gag straightener.
12. Combination beam and channel shear.
13. 12-in. Mill furnaces.

Figure 1 — The Saucon division boundaries are such that room for expansion is limited.

14. Coke breeze conveyor system.
15. Shipping yard office building.
16. Shipping yard welfare building.
17. Auxiliary shipping yard office building.
18. A total of 18 new cranes.

The above mentioned major items required considerable alterations to present buildings, either by dismantling the old buildings and erecting new structures to permit greater head room, or to strengthen the building to carry the heavier equipment.

It also required alterations to cranes, present gag straighteners, mill tables, yard tables, office and welfare facilities, storm and sanitary sewers, besides numerous field changes that were impossible to foresee when layouts were only in the preliminary stage.

It was also decided to renew the 46-in. blooming mill engine bedplate, and, in so doing to change the location to install a new lead spindle between the pinion stand and the engine. Since the center distance between the pinion stand and the engine was increased, this required dismantling of the old engine foundation and the installation of a complete new foundation.

In addition to the major items mentioned, it was also necessary to install a considerable amount of yard roller tables to expedite the handling of structural shapes from one runway to another.

Where new equipment was called for it was only natural that new foundations were installed, but since these included scale-flushing tunnels and pits, it was necessary, in some instances, to provide new foundations under much of the old equipment.

Furthermore, there were cases where it was necessary to replace the old equipment with new material when being dismantled for these new foundations. Much of this was made necessary when it was found practically impossible to adapt the new parts to the old and still expect good operation.

One of the most troublesome points in a program of this type, from an engineering point of view, was the uncertainty of what was underground that might

cause interference and necessitate alterations during construction. Doubtful locations of water lines was one of these problems.

While aware of the fact that other plants have had the same problems when installing new equipment, it is doubtful if many steel plants have had as congested conditions to deal with as in the Saucon division.

The plant maps were no doubt as reliable as they could possibly be, but no previous elevations or clearances were taken for granted in making the plans for installing any of the new equipment. Complete field surveys were made to establish elevations and clearances.

Another problem that is always present in major programs such as this is that of uncertainty regarding installations made many years ago. There is always the question whether it was originally installed according to plans drawn up at the time or if alterations were made which might never have been properly recorded on the drawings in the files. This, of course, necessitated new surveys and a tremendous amount of time to clear up, especially where it was necessary to do excavating to obtain the information required.

The program was started in October, 1953 and is expected to be completed the latter part of 1956, about three years from the start of engineering.

In the layout of the equipment planned for this program, very little bearing or sheet piling was required, with the exception of those places where depth of excavation made it necessary to protect column footings or where water lines had to be protected.

Another point was the matter of water problems usually encountered in deep excavations. Saucon division is approximately 65 feet above river level and therefore presents no difficulties along this line.

As previously mentioned, practically all of the equipment installed was located in close proximity to the old mills and furnaces. An exception to this was the auxiliary shipping yard where it was planned to handle all slitting and cambering operations, segregating these operations from the regular beam shipping yard. Figure 2 shows this layout.

After deciding upon the area required for this Tee bar set-up, the yard was laid out at an angle to that of the majority of the plant buildings which are practically all either east and west, or north and south.

This section was laid out in this manner to make use of the fill that was already there and permitted continuing the balance of the fill required to bring in the trackage necessary for handling material from the beam shipping yard and outgoing shipments.

All of the designing of the equipment involved in this improvement and the sequence of installation was based on maintaining continuous operation of our

Figure 2 — All splitting and cambering are being done in the auxiliary shipping yard.

Figure 3 — New soaking pits were installed on the site of the old furnaces.

Figure 4 — The 40-in. No. 1 blooming mill was dismantled completely.

Figure 5 — Ingot is shown on an approach table on the new 40-in. No. 1 bloomer.

present mills; with any downtime of individual units reduced to a minimum.

As mentioned elsewhere in this paper, all the mills in this division where alterations had been planned were driven by steam engines. However, the new 32-in. bloomer just installed, is driven by a 5,000-hp motor, 700-volt, 70/140-rpm, supplied by a 5,000-hp synchronous motor-generator set with variable voltage control.

New substations were built for the 40-in. No. 1 bloomer and for the 32-in. blooming mill. The whole expansion program required additional power facilities since the previous set-up was inadequate and had to be brought in line to handle the proposed increased tonnages.

The congested areas throughout the Saucon division made it extremely difficult to find suitable locations to bring in some of the lines clear of the old equipment and still not interfere with the new installations.

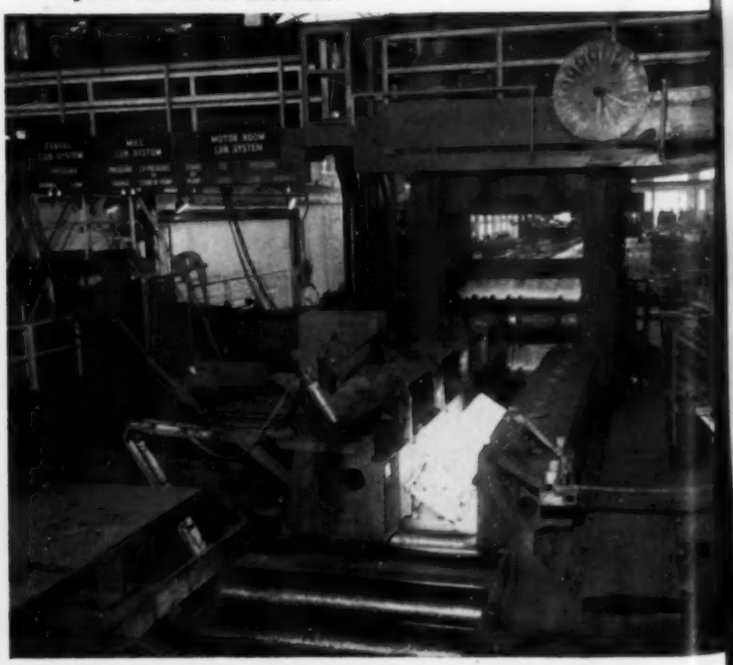
While it is quite certain the time will come when all the old steam driving units will be replaced by electric motors, there are so many points to be considered in a layout such as exists in this division that it never seems to be the right time to make the change when new improvements are contemplated.

The new soaking pit furnaces (shown in Figure 3) were installed on the site of our old pit furnaces, requiring complete dismantling of the equipment in that area, with everything new from bottom of foundation, using a portion of the old building, but adding a lean-to to accommodate the new design furnaces and their controls.

A modern coke-breeze conveyor system was installed in the soaking pit furnace building, eliminating the antiquated handling methods previously used.

The 40-in. No. 1 blooming mill, as shown in Figure 4, with its tables and manipulators, was dismantled completely, including complete removal of all the old foundations under the tables and a portion of the mill shoes.

Figure 6 — The 32-in. blooming mill is installed in an area beyond the 40-in. bloomer.



The engine and pinion stand were retained, but all other equipment was new.

The front and rear tables, with their electric manipulators, were designed for tandem rolling of ingots which are delivered by 20-ton soaking pit cranes to a loading table at the front end of the approach table leading to the mill.

Figure 5 shows an ingot on the approach table, after having been deposited on the loading table by the soaking pit crane and ready to pass underneath the operator's pulpit, beyond which can be seen the front mill table. A turn-table, electrically operated, is located at the junction of the ingot-loading table and the bloomer approach table.

The 32-in. blooming mill was installed in an area beyond the 40-in. No. 1 bloomer shear and occupies the space previously used for the runout table from the 40-in. No. 1 bloomer to the billet shear. The entry side of this mill is shown in Figure 6. This was a complete new mill, including new electric motor drive, pinion stand, front and rear tables, and manipulators.

A new 500 ton bloom shear was installed between the 32-in. bloomer and the feed table for the 28-in. mill furnaces.

Two new furnaces were installed for the 28-in. structural mill, as shown in Figure 7 and new tables, entering and delivery, were added to the old 28-in. mill roll train, replacing tables that had been in use for the past 45 years.

When rolling billets on the 32-in. bloomer, they are kicked off into billet buggies, spotted at their proper location by means of an under-floor chain and dog-type of drive. Figure 8 shows the inclined skids for kicking off the billets into the buggies. This is chain operated and is equipped with a hinged portion at the discharge end to allow for locomotive clearance.

For handling slabs off the 40-in. bloomer, new slab cranes and transfer cars were installed, making it possible to deliver the slabs to the storage yard without operating over the 48-in. mill tables as was previously done, necessitating the removal of mill rolls in the finishing mills to get the slabs out into the yard.

Figure 9 shows the slab transfer just beyond the 40-in. No. 1 bloomer shear, with the slab kick-off shown in the lower right hand corner. Slabs are merely delivered off the table and allowed to drop to floor elevation, between vertical guides on either side of slabs.

The table shown to the left on the picture is the approach table leading to the 32-in. bloomer.

A double 30-ton trolley slab crane delivers slabs to the slab car. These loads are picked up from the slab piler beyond the 40-in. No. 1 shear.

Figure 10 shows the slab storage yard, where slabs from the mill are stored preparatory to shipping. The picture shows a 30-ton slab crane, equipped with two independently operated trolleys, and also shows quite clearly the new 98-ft span runway, rigidly tied with overhead trusses. This type of runway is now considered as standard design for open runways in our Bethlehem plant.

The 42-in. and 48-in. mill hot beds were both increased in length, and a change made to the drives of

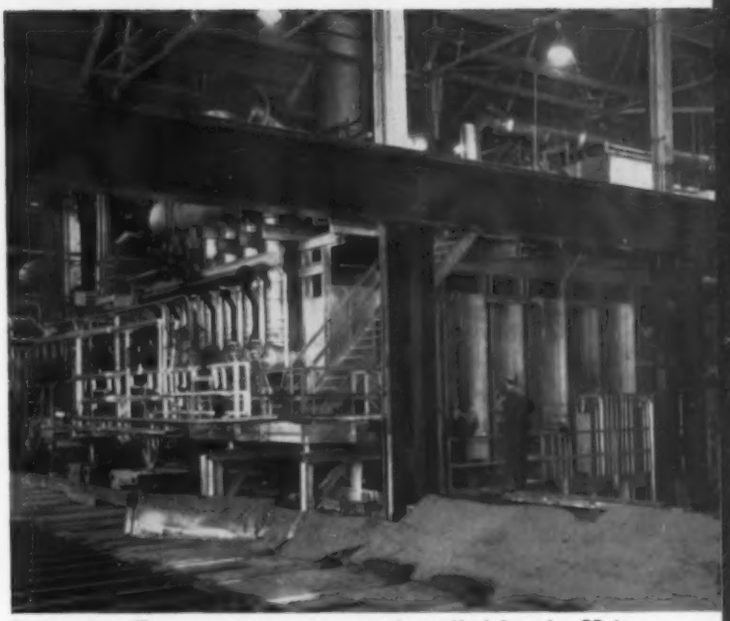


Figure 7 — Two new furnaces were installed for the 28-in. structural mill.

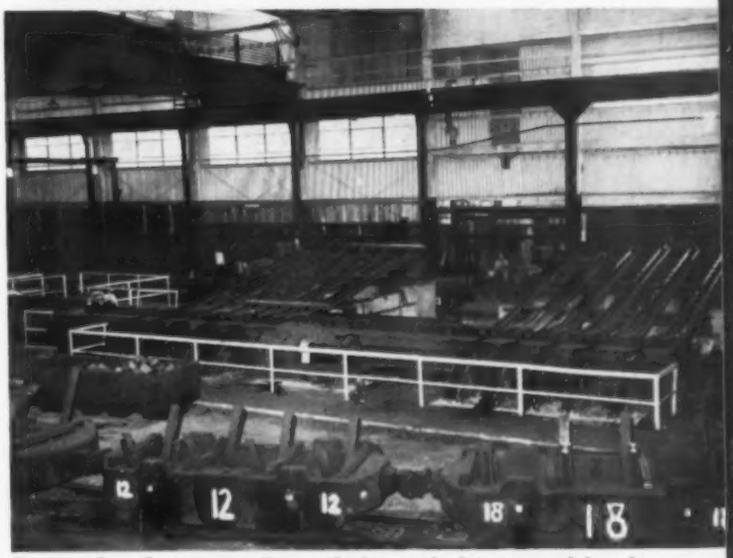


Figure 8 — An under-floor chain and dog-type drive is used on the billet kick-off.

Figure 9 — Slab transfer is shown just beyond the 40-in. No. 1 bloomer.

Figure 10 — A new 98-ft span runway of standard design serves cranes in the slab storage area.

both hot beds to facilitate better handling of short pieces. The 48-in. mill hot bed had been 215 ft in length and was divided into two sections of equal length, with two individual drives. This was lengthened out to 270 ft and divided into four equal length beds, with four individual drives. The 42-in. mill hot bed had been 210 ft in length, in three equal sections, each with its own drive. This bed was lengthened to 278 ft and divided into four equal-length beds, each with a separate drive. The new extension carries out into the space formerly occupied by the yard office.

The entire old hot bed area of both the 42-in. and the 48-in. beds was completely dismantled and with the new extensions was deepened to a depth of 13 ft from the top of skids to the floor line under the bed, giving us a 9-ft clear headroom underneath the skid beams supporting the bed. A view of this depth can be seen in Figure 11, which shows the excavation necessary to obtain this overhead space.

This permits excellent circulation of air under the bed and helps materially in faster cooling of the sections before sending them out to the yard for straightening and sawing.

A new 60-in. hot saw was installed in the head table of the 42-in. hot bed, approximately 90 ft from the tail end of the hot bed. This saw relieves the heavy load on the 60-in. hot saw located at the entrance to the hot bed head table.

These changes to the two hot beds necessitated dismantling of a large shipping yard office building which occupied the space needed for the extension. This made it necessary to erect a complete new office building elsewhere.

This new shipping yard office, a two-story building, was located just a short distance from the one end of the shipping yard, being close enough to be readily accessible, yet away from much of the noise. These offices are well lighted and completely air-conditioned.

A new order and metallurgical office building was erected some distance from the shipping yard, but close to one of the main entrances to the plant.

A complete new pneumatic mailing tube system was installed between the shipping yard and order

Figure 11 — The entire old hot bed area was dismantled and new extensions added.

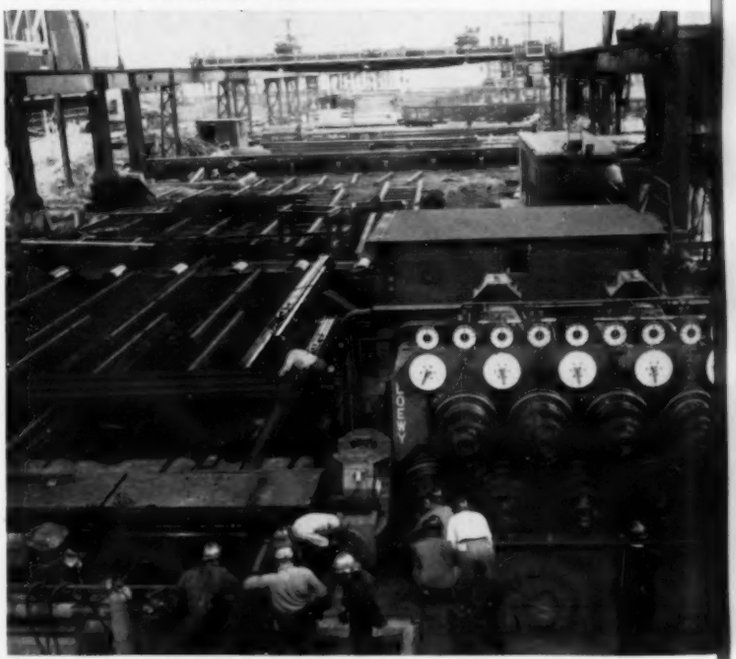
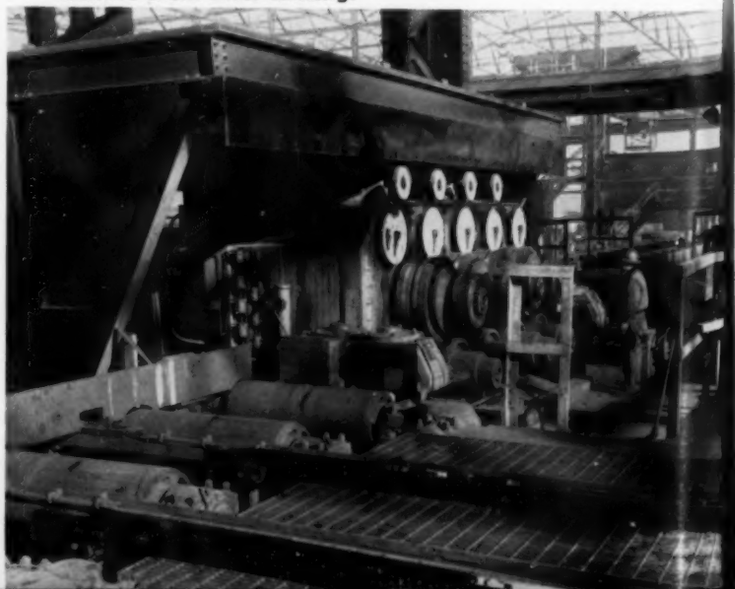


Figure 12 — Straightening equipment in the shipping yard was completely revamped.

Figure 13 — A special rotary straightener for Tee bars handles them after slitting.



offices and is exposed above ground at some points and underground at others.

A complete revamping was made of the straightening equipment in the shipping yard. Transfers and piling beds were moved to suit the new gagging facilities, and also the new design rotary straightener, shown in Figure 12, which was installed in the runout table from the 42-in. mill. This straightener handles wide flange beams, while the rotary straightener for Tee bars, as shown on Figure 13, handles bars after slitting. This unit is located in the auxiliary shipping yard shown in Figure 2.

A new 600-ton combination beam and channel shear was installed, together with new tables and gage, making it possible to eliminate considerable load on the cold saws. This unit is shown in position just prior to setting up on foundation.

Our shipping yard covers an area of approximately 25 acres and is made up of three runs of 320 ft each, one run of 540 ft, four runs of 600 ft, and nine runs of 880 lineal ft each. Figure 14 shows a typical cross section through one of these 17 runs.

One of the crane runs, our No. 5, was roofed over for a distance of approximately 225 ft.

The balance of this yard is made up of open runways, with a total of 52 10-ton cranes handling the shipments of the structural sections going through this yard.

During the construction of this equipment, we also installed 6500 lineal feet of new black top roadways, 5400 lineal feet of new storm sewers of various sizes, 7400 lineal feet of new standard gage track, and relocated or removed 5100 lineal feet of standard gage. We also installed 2500 lineal feet and removed or relocated 2300 lineal feet of narrow gage track.

CONSTRUCTION

By R. L. WILLIS
Superintendent of Construction
Bethlehem Steel Co.
Bethlehem, Pa.

▲ THE first project on which field work started was the new auxiliary shipping yard. It was first necessary to install two sections of gas main, one to replace an old cast iron line being buried under approximately 40 ft of fill, and the other to replace a steel line that interfered with the concrete foundations. The site sloped downward toward the south and the new yard was located to equalize cut and fill in the immediate area. It was located also to permit transfer of an existing 6900-volt transmission line to new towers on the west elevation of the new steel framework. In erection, one section of three bays had to be left out of the west elevation, being the location of the old transmission line tower, until the lines were transferred to the new towers. Figure 15 shows field erection of No. 1 gag and

Figure 14 — Shipping yard covers an area of about 25 acres.

gag house with the rotary Tee bar straightener visible to the left of the brick control house. Note the close working quarters with the yard being used by the operating group for storage and sorting purposes.

At the same time the yard installation was being made, a bridge for railroad access was being installed over the main traffic artery to the east from the south section of the City of Bethlehem. One-way traffic was established from the time the truck arrived with a girder until the lift was to be made. Traffic was then halted until the girder was in place on the shoes. The period during which traffic was at a standstill was less than ten minutes for each girder. Figure 16 shows the second girder almost in place. Bearing pile was used in the abutment footings and the required fill was obtained from normal plant refuse.

Another project on which work started early in the program was the installation of the new soaking pits. In order to minimize interference with operations it was decided to install two batteries and have them operating before starting on the remaining two. The first two required the removal of one row of old pits and one preheater, whereas the third and fourth required removal of three old rows of pits. Since the west wall was in the clear, we proceeded with that section for batteries No. 3 and No. 4 also. Piling was required to maintain the original stack foundations and a storm sewer on the east side of the wall, and a

Figure 15 — Field work was first started on the auxiliary shipping yard.

Figure 16 — It was necessary to install a bridge for railroad access over a main traffic artery of the city of Bethlehem.

standard gage track on the west that supplied coke breeze for bottom making. Metal forms were used for many of the foundations because they could be reused several times resulting in economic benefits. A temporary support under a main steam line to another department was required to permit excavation. The base was bearing pile and cross bracing was added as excavation proceeded. A girder change was required on the east side of the building to provide for three narrow gage tracks instead of two between batteries No. 2 and No. 3. Figure 17 shows the building change on the west side; also the stack for No. 1 battery, the erection derrick, and the pulling of sheet piling. The cut off blast furnace gas main to the old No. 1 row and preheater is seen on the right and the gas main to No. 5 boiler house remaining in service during construction is near the top of the picture. The steam line and support are also visible. The change consisted of erection of the double girders, one on each side of the old building columns. After completing connection of the columns to the girders, the bottom sections of the old columns were removed leaving the long span area for installation of the new soaking pits. Figure 18 shows further progress. Prior to completion of batteries No. 1 and No. 2, with operations somewhat reduced, it was decided to proceed with batteries No. 3 and No. 4 in order to gain time, complete connecting tunnels and relocate trackage. Figure 19 shows the lean-to, gas piping, and controls for batteries No. 1 and No. 2 nearing completion, and the pit tub and support piers being installed for batteries No. 3 and No. 4. The complete view of the four batteries was shown in Figure 3.

Installation of the 32-in. mill first required the removal of the old 500-ton billet shear and considerable length of old runout table. First excavation started was for the motor room. The entire ground area for this new mill was shot through with old mill, pinion housing, and table foundations, which machinery had been removed years ago, but the foundations only cut off below grade. Sheet piling was required to contain existing building piers and a narrow gage transfer track. A crane run support girder, similar to that installed at the soaking pits, was required to remove existing building columns which interfered with the motor room and mill tables and manipulators. In order to assist the carpenters, and supervisors, in visualizing the outline and contours of the base slab for the mill foundation, a scale model was constructed. It was of invaluable assistance. Unfortunately, no photograph was taken. Figure 20 shows the site after the base slab was poured. The mill shoe anchor bolts and pinion housing anchor bolts were suspended as shown to hold them in position for the pouring of the base slab, which contains approximately 1200 yards of concrete and required twenty-four hours to pour. Note the bricking of the motor room walls with panels omitted for entrance of equipment. The reinforcing bars extend from the motor foundation dowel into the second and final pour of the mill foundation. Installation of conduit is under way as seen along the motor room wall. Conduit also extends to the background for the transfer tables and billet shear. Scale sluice, air ducts from motor room to mill, table, and manipulator motor locations, and start of forming for the second pour are seen. Two cranes with a lifting beam were required to bring in the motor-generator set motor stator.

The two new furnaces for the 28-in. structural mill were to be built practically on the site occupied by the two old furnaces. This required operation of the mill on one old furnace while the other was dismantled and the new one built in its place. The new furnaces were longer than the old, and the discharge table had to be

Figure 17 — Sheet piling are being pulled at the west side of the soaking pit building.

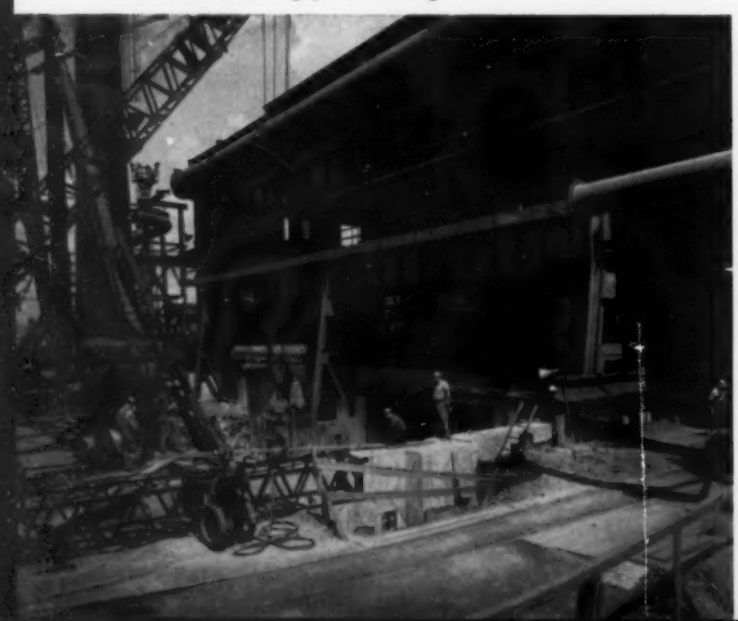


Figure 18 — Soaking pit batteries No. 1 and 2 were constructed first.

Figure 19 — View shows lean-to, gas piping and controls for No. 1 and 2 batteries which are nearing completion.

Figure 20 — Base slab for 32-in. mill has been poured in this view.

maintained in line with the mill tables. Therefore, the approach table location was to be changed. As the stock approach to the furnaces and discharge from them were both east of the furnaces, the west furnace was rebuilt first. As the 32-in. mill neared completion, the demolition of the old west furnace was started. The old furnaces were equipped with waste heat boilers which were 40 years old. The new furnaces are not equipped with waste heat boilers. Excavation for the new west furnace extended practically against the old east furnace with the west platform at this furnace overhanging the excavation. The furnace discharge table is built for scale flushing and the connection to the 40-in. No. 1 mill scale pit was installed under existing roll storage racks by tunneling. The approach table location was changed to the position of the old pushers. Therefore, the pusher and motor for the operating old furnace were in the way of the installation of the approach table to the new furnace. A shutdown of the mill was taken for thirteen days (during which time mill vacations were scheduled) to remove the necessary approach and discharge tables for the old east furnace, and part of the furnace, and install the new tables, including the pusher for the new east furnace. Upon resumption of operations, the new west furnace was in use and the old east furnace incapable of use. This shutdown started three weeks after the shutdown of the 40-in. No. 1 mill which normally supplied the 28-in. mill with blooms. Figure 21 was taken after the three-week shutdown, and shows the partially dismantled east furnace, the temporary monorails used for dismantling and later for erection, the bridge over the 28-in. mill entry tables, and the new west furnace. The new furnace discharge roller line is in the foreground and the approach roller line is in the background. This figure gives some indication of the limited working space, a line of building columns being just to the right of the photograph.

As much preliminary work as possible was done for the 40-in. No. 1 mill prior to the shutdown, such as the crop transfer pit wall, the slab storage crane run, the slab storage crane, and the slab transfer crane. The slab transfer crane run was 80 per cent completed. Due to interference with operations, the balance of the slab transfer crane run awaited the mill shutdown. A new substation serving as a distribution center, the second floor of which contained all the controls for the new mill auxiliaries, had been completed. Also completed were the scale pit and its sewer connection. Concrete was pumped and also supplied directly from trucks. The sluice from the 40-in. No. 1 mill enters the north end, that from the 28-in. mill from the east, provision is made for a future sluice from the 46-in. mill in the south wall, and the overflow is in the west wall. A recirculation system was provided, with the connection to the sewer at the pumphouse.

After operating the 32-in. mill for seven weeks, during which time some ingots were brought directly to this mill from the soaking pits by narrow gage transfer for trial and practice purposes, the 40-in. No. 1 mill was shut down for installation of the new mill, tables and manipulators. Figure 22 was taken on the thirteenth day of shutdown. In the background are seen the new soaking pits, and the old approach table

Figure 21 — Working space was very limited for the construction operations.

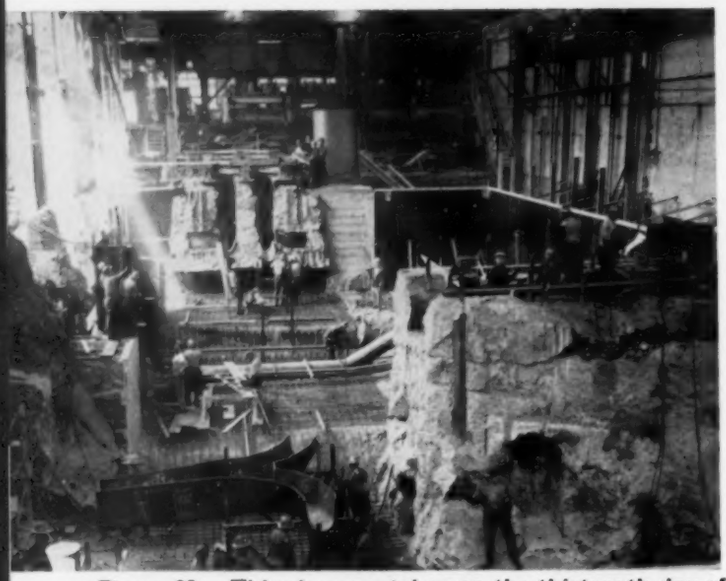


Figure 22 — This view was taken on the thirteenth day of the shut down of the 40-in. No. 1 mill.

Figure 23 — The shipping yard office building and welfare room had to be shortened to get room for the new equipment.

Figure 24 — Excavation is shown for the hot bed extension.

foundation which is being adapted for scale flushing, with two sections of sluice in place. The junction section of the scale flushing sluice also is in place. The pulpit foundation is complete and the pulpit supports are erected. Also seen are reinforcing, air ducts, forms, and the old foundation for the pinion housing which foundation is to remain. The piece of concrete in the near corner of the pinion housing foundation was removed after the base pour. Conduit drops are installed along the face of the substation wall and conduit is being installed in the trench from the substation to front and rear manipulators and tables. After all conduit was completed, it was encased in concrete. The base slab, approximately 525 yards of concrete, was another case of pouring by a combination of pumping and direct discharge from trucks. On the sixteenth day of shutdown, the pulpit was in place and controls were being installed. The total length of shutdown was forty-three days, one week less than the original schedule. The completed mill and slab kick-off are shown in Figures 4 and 9.

Extension of the 42-in. mill hot bed and the building required the demolition of the shipping yard office building. Bridges were built over two roller lines from the 48-in. hot bed, with a ramp to gain access to the office with mobile equipment. The old office and the welfare room which had to be shortened are shown in Figure 23. The crane run was later covered and the gag, with the pulpit in the foreground, was relocated. Two bays of the hot bed building were dismantled for changes, including elimination of one column for the hot saw installation. Excavation for the hot bed extension is shown in Figure 24. In the left background is seen the old runout table. Note the depth of excavation as compared with the floor elevation of the old hot bed. The new roller table was partially assembled on falsework. Before completing the foundations for the hot bed extension, No. 3 section (1/3) of the old hot bed was removed and the foundations installed for the balance of the new runout table. On a mill shutdown, the new table was skidded into position. The hot saw is installed between these two sec-

Figure 25 — Hot saw is installed between No. 3 and No. 4 sections of the hot bed.

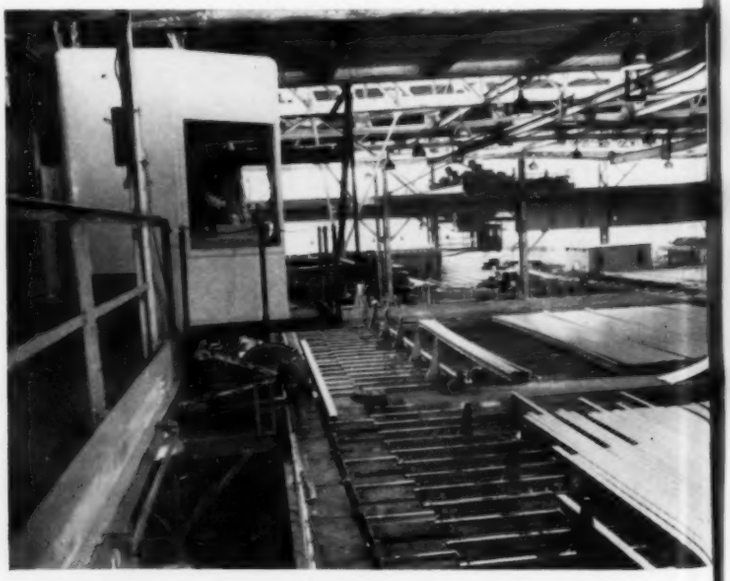


Figure 26 — It was necessary to skid the gag into position because of the weight of the gag.

Figure 27 — The rotary beam straightener was installed at this location.

tions of bed. The completed No. 3 and No. 4 sections are seen in Figure 25 with the hot saw visible behind and below the pulpit. Rebuild of the remaining two sections of the old hot bed proceeded in a manner similar to the rebuild of No. 3 section, that is, number 1 and 2 sections were dismantled, excavation and foundations followed, with completion of No. 2 section accomplished while continuing work on No. 1. This work was within the old building and access was from the opposite end of the building.

Installations in the shipping yard included the rotary beam straightener, a gag straightener, the beam and channel shear, and several gag relocations with new tables and beds. Since problems were similar, illustrations will be of typical construction and not of all installations. The installation of the new No. 10 gag entailed removal of the old No. 1 gag which was reconditioned and installed in the auxiliary yard. The location is between another gag and the runout table from the 48-in. mill, and all excavation, concrete, etc., had to be handled by overhead crane. The main feature of interest is that the gag weight exceeded the capacity of the overhead crane, making it necessary to skid the unit into position. The base was lifted off the railroad car by two crawler cranes and set on the skids. Partial assembly was accomplished followed by skidding. Figure 26 shows the crossing of the entry roller table for an adjacent gag. As soon as the crossing was complete, the bridge was removed and the table side guards were replaced, permitting resumption of operation. It was necessary to skid the machine south, then jack it down on to other skids to move it east. When the gag was in position it was lowered to the foundation by use of jacks.

The rotary beam straightener was installed in the approximate location of another gag. However, it was partially in the old entry bed, and in the covered run mentioned previously in connection with the 42-in. mill hot bed. Figure 27 shows the site, with the gag

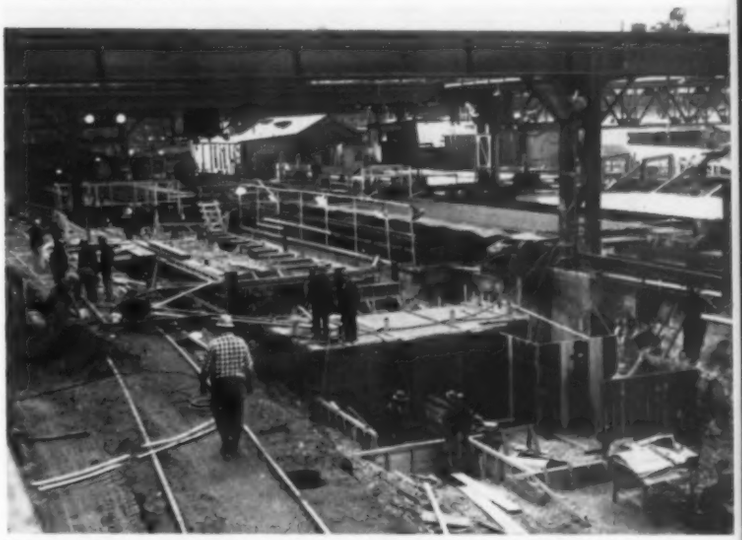


Figure 28 — Installation of new beds for gag No. 4 and 5 presented an interference problem with production operations.

Figure 29 — Excavation is shown for the discharge bed on the eighth day of shutdown.

removed and excavation started. The old entry and discharge beds remained, but were extended and supplied with new skids. A new runout table was placed in near run as part of the extended discharge bed. Alternate piers were removed from under the old table and the new piers installed. The new table was installed on the new piers, and then the remaining old ones removed and the new piers completed. The rotary beam straightener was also too heavy for the cranes and resort was made to skidding.

The relocation of two gags (No. 4 and No. 5), with installation of new beds, presented the problem of interference with yard operations to a greater extent than any other work discussed. The first step was completion of as much work as possible for the No. 5 gag relocation before shutting down the unit. The new discharge bed is located in the original area of the gag. Figure 28 shows the old gag house and entry bed and table with a crane run girder change completed, the new gag foundation, and formwork for the new entry bed, all prior to shutdown. The excavation at the left is for the control house which is located beneath a roadway. As soon as the gag was shut down, concentration was on excavation and completion of the uncompleted portion of the entry bed, and on relocation of the gag and excavation for the discharge bed. Operation of the entry bed for piling and shipping purposes was on 22nd day. Figure 29 shows excavation for the discharge bed on the eighth day of shutdown. Note that the side of the house for adjacent No. 4 gag has been removed for this bed excavation. In a similar way, preliminary work for No. 4 gag was started while No. 5 was shut down. Original plans were to operate No. 4 until No. 5 was complete. However, about one week before scheduled completion of No. 5 it was found that the interference of the discharge bed with No. 4 was so severe that this bed could not be completely excavated without a shutdown of No. 4. Plans were changed to remove No. 4 gag earlier. This delayed operation of No. 5 gag five days, but completed the discharge bed at the same time, and further resulted in at least one week earlier completion of No. 4 gag. Figure 30, taken on the third day of No. 4 gag shutdown, shows the roller table being installed at the discharge side of the No. 5 gag assembly bed. The old approach table to No. 4 gag, also visible, is to be removed and a transfer bed installed from the new roller table to that beyond the clamshell which is excavating for this bed. Figure 31 shows form work progressing for this transfer bed with the No. 4 gag entry bed nearing completion. No. 4 gag is in its new position and the gag house is being erected. Of interest is Figure 32 which shows protection of transfer bed foundations poured in sub-freezing weather. Coke salamanders were used with the sheet metal protection. Openings were maintained for exhaust of combustion gases and circulation of fresh air. In this figure, No. 4 gag is completed and is operating. The shutdown of No. 5 gag was for twenty-six days and for No. 4 gag nineteen days, as compared with the original estimate of four weeks for each.

OPERATIONS

By R. W. COUCH
Superintendent Mills and Shipping Yard
Bethlehem Steel Co.
Saucon Division
Bethlehem, Pa.

▲ ONE of the early announcements of the objective of the heavy structural steel expansion program appeared in the Iron and Steel Engineer of September, 1953, from which I quote: "Ingot producing capacity of the Bethlehem Plant of the Bethlehem Steel Company will go up about 15 per cent," according to S. J. Cort, vice-president of operations of the company. "This increase will come through a greater supply of hot metal from new blast furnaces and through improved fuel conditions in the open hearth." Mr. Cort said that "the program of enlargement, modernizing, and rebuilding at Saucon division will provide a 50 per cent increase in the capacity of the structural mills there, with primary emphasis on wide flange beams

Figure 30 — Roller table is being installed at the discharge end of the No. 5 gag assembly bed.

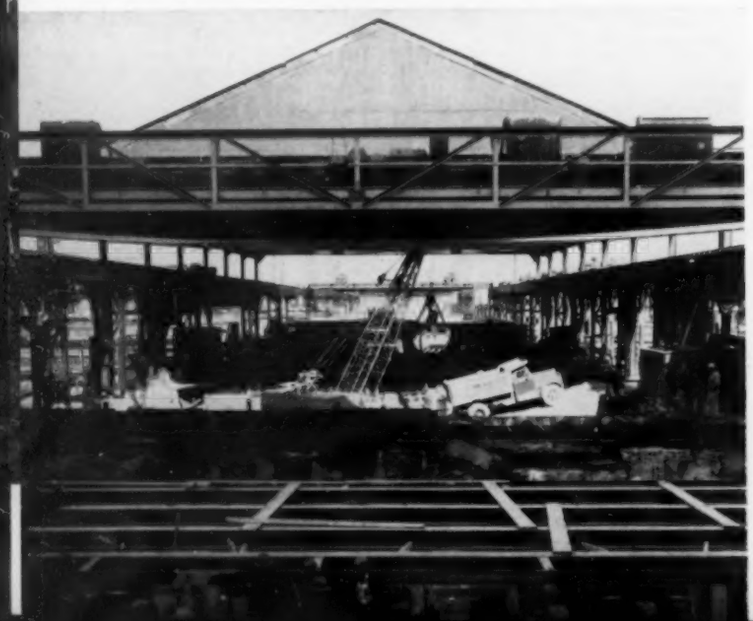


Figure 31 — No. 4 gag entry bed is near completion in this view.

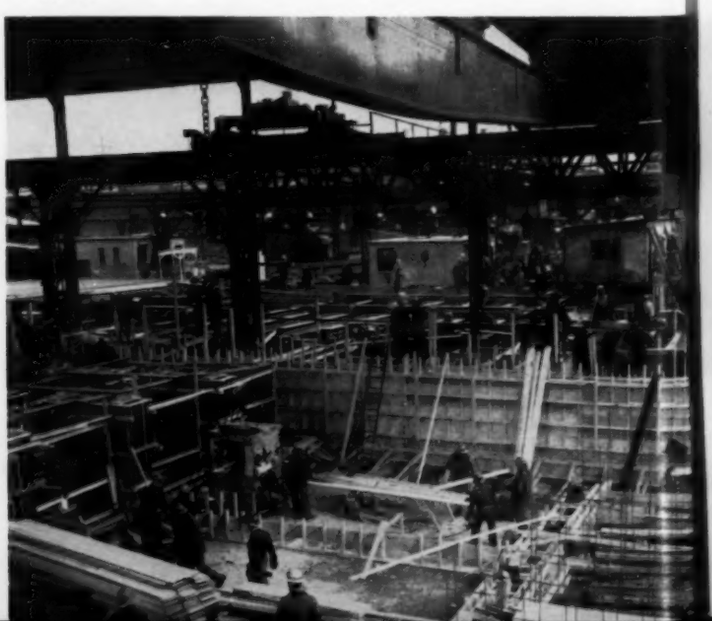


Figure 32 — Foundations for transfer beds were poured in sub-freezing weather necessitating protection.

pointing toward an increase of 60,000 tons, and 10,000 tons of standard product per month."

This announcement of a 210,000-ton objective per month followed the completion of increased coke oven and blast furnace capacity which rounded out the raw material program at the Bethlehem plant.

In this 45-year old plant that was producing more than twice the tonnage for which it was originally designed, many bottlenecks in production had developed throughout the years. Some of these were heating, straightening, cold-cutting, and shipping. Others were the results of demands for special services to customers, such as slitting and cambering which had been provided within the confines of the main yard. This area also became congested because of a gradual change in the character of business, and a demand for increased tonnage, which is illustrated by the fact that between the record years of 1929 and 1953, shipments of structural tonnage increased by 41 per cent while the average weight per foot rolled decreased by 47 per cent, thereby adding a heavy burden to existing rolling and handling equipment.

This program fell quite naturally into three parts from the operating point of view: (1) heating, (2) rolling, (3) finishing and shipping facilities. An ideal approach to the installation of these facilities, so far as the engineering, construction and service divisions are concerned, would be to shut the various sections down, install the facilities, and resume operations. However, our problems could not be resolved in that way, for we were committed to consume the product of our open hearth that was frequently establishing new monthly production records.

From the start, it was obvious that any construction undertaken as part of this program would have a detrimental effect on producition with the single exception of a new auxiliary shipping yard, which was located in another section of the plant and was planned to receive a portion of the overflow of the main yard. While the sequence of installation was controlled to a great extent by delivery of equipment, all plans were made to minimize production losses. The irony of installing improved equipment was that the next plan called for the removal of other equipment that would for a time minimize the use of the new facility.

These facilities will be described under the headings of heating, rolling and shipping.

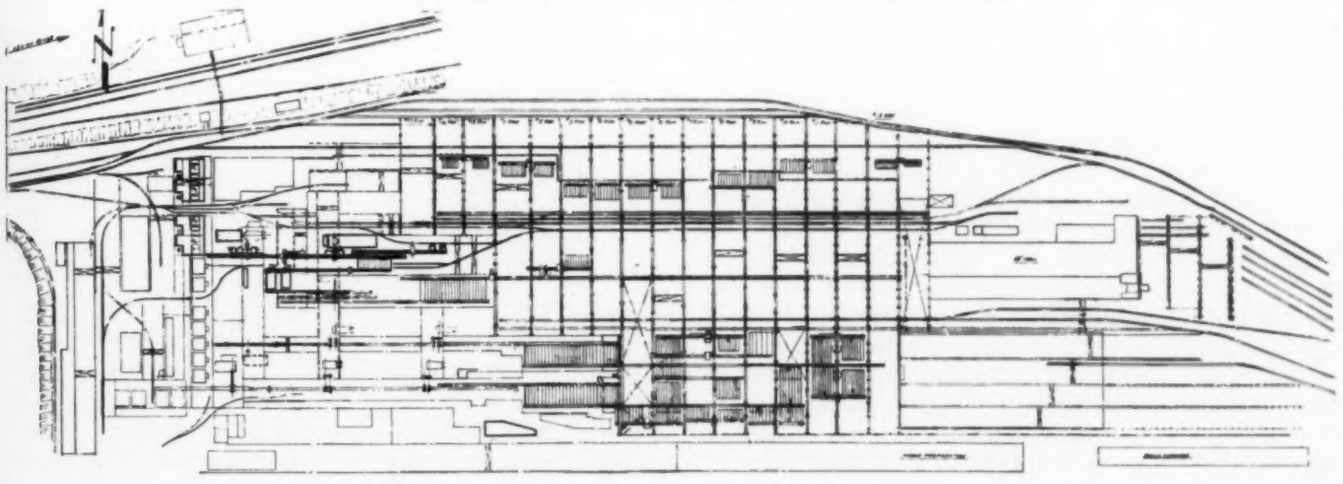
HEATING

Figure 33 is a general layout of Saucon mills and shipping area. The No. 1 and No. 2 soaking pit buildings shown of the upper mill area consisted, before construction, of 15 rows of regenerative-type pits and a preheater with a total of 3344 sq ft of hearth area.

By removing four rows of these pits, shown on the north end of No. 1 pit building and installing four batteries of four holes each of end-fired recuperative pits (9 ft x 25 ft), we now have 6067 sq ft of hearth area, reflecting an 82 per cent increase in total hearth area. A new 20-ton crane was provided in the new pit section, as well as a new natural frequency vibration coke breeze conveyor with three selective delivery locations in the two buildings. Construction is now under way for replacing rows 5 and 6 with recuperative type pits which will provide an overall increase of 118 per cent in heating area in the original building.

The No. 1 pit building is being extended northward and two ingot tracks are brought through this section in order to keep the flow of steel toward the mill. This building is also being extended southward to facilitate

Figure 33 — General layout of Saucon Mills and shipping area.



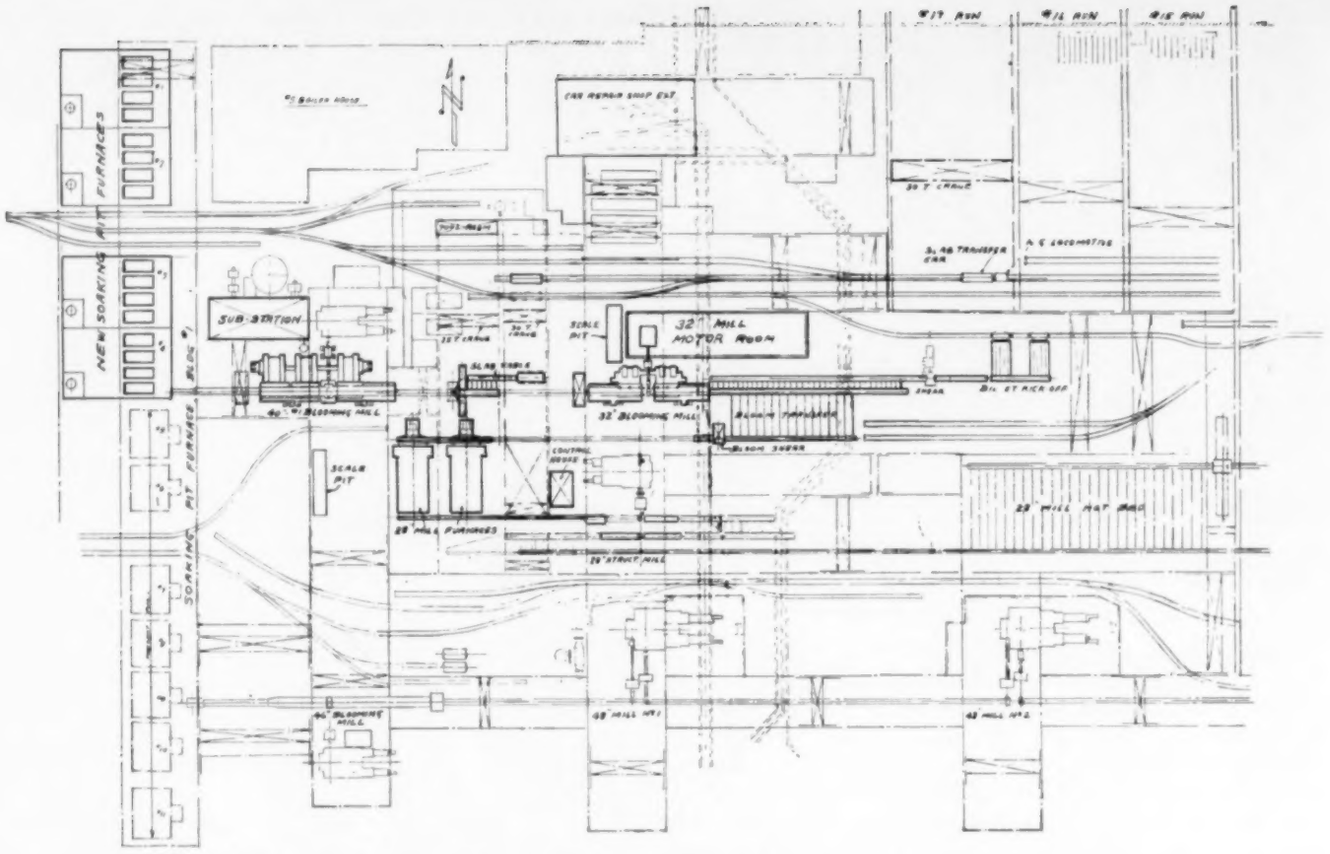


Figure 34 — Arrangement of new mill equipment in heavy structural expansion program.

the charging of ingots in the old pits. An ingot roller line and turntable are also being provided in front of batteries No. 3 and 4 to ease the problem in feeding the new combination mill shown on the north side of the slide.

Future potential for increased capacity can be obtained by replacing additional regenerative pits in this building, if desired.

ROLLING MILLS

Before the expansion program, Saucon structural mills consisted of three blooming mills and five finishing mills. Two of the bloomers were 40-in. and one 46-in.; two of the finishing mills were universal wide-flange units and three were standard mills. They produced 137 sections in 435 weights, ranging from 1 x 1-in. angles at 0.8 lb per ft up to a 36-in. beam at 300 lb per ft and a 14-in. column section at 427 lb per ft. Included are miscellaneous angles, bulb angles, channels, Zee bars, etc. One 40-in. blooming mill was replaced and a 32-in. blooming mill added; otherwise no changes were made to mill equipment as part of this program.

On the lower half of the upper mill section is a diagram of the 48-in. and 42-in. wide flange mills which are served by a 46-in. and 40-in. No. 2 blooming mill respectively. The 48-in. mill was the first wide-flange mill to be placed in service in this country, and was designed by an Englishman, Henry Grey. An issue of Iron Age, in 1908, comments on the placing of this mill in production and states, "it is an event not without significance in connection with the widening of the field for steel as a material of construction." It further comments on the original Grey Mill at Differdingen, Germany, and in effect states that with refinements, this larger mill, and the use of two Grey mills as an intermediate and finishing unit, the production potential was being considerably increased. This mill was designed to roll a maximum 30-in. wide-flange beam; however, in 1928, a 33-in. and in 1932, a 36-in. wide-flange beam was added to the production of this mill. The 42-in. wide-flange mill was placed in service in 1919, and complements the production of the larger mill by rolling from a maximum 18-in. beam down to the various small joist sections. Flexibility is maintained by being equipped to roll many of the heavier 42-in. mill sections on the 48-in. mill. The production potential of these two finishing mills has never been realized because of restrictions in the heating, straightening, and shipping facilities; therefore, the construction program calls for no change in these two mills in order to produce an additional 60,000 tons of wide-flange per month. Auxiliary changes include two engine bed plates, five sections of roller lines, rebuilding and enlarging the two hot beds by approximately 30 per cent, and adding a second hot saw on the 42-in. mill.

During idle time on these two finishing mills, due to restrictions, the 40-in. No. 2 blooming mill had rolled billets for the 12 and 18-in. standard mills and the 46-in. blooming mill had rolled slabs for the Sparrows Point plant. In the new program, this blooming mill capacity would be utilized for wide-flange production, and a study indicated this loss in slab and billet capacity could be compensated for and the necessary gain realized by replacing the 40-in. No. 1 blooming mill with a new 40-in. blooming mill and adding a new 32-in. blooming mill in line, as shown on the upper

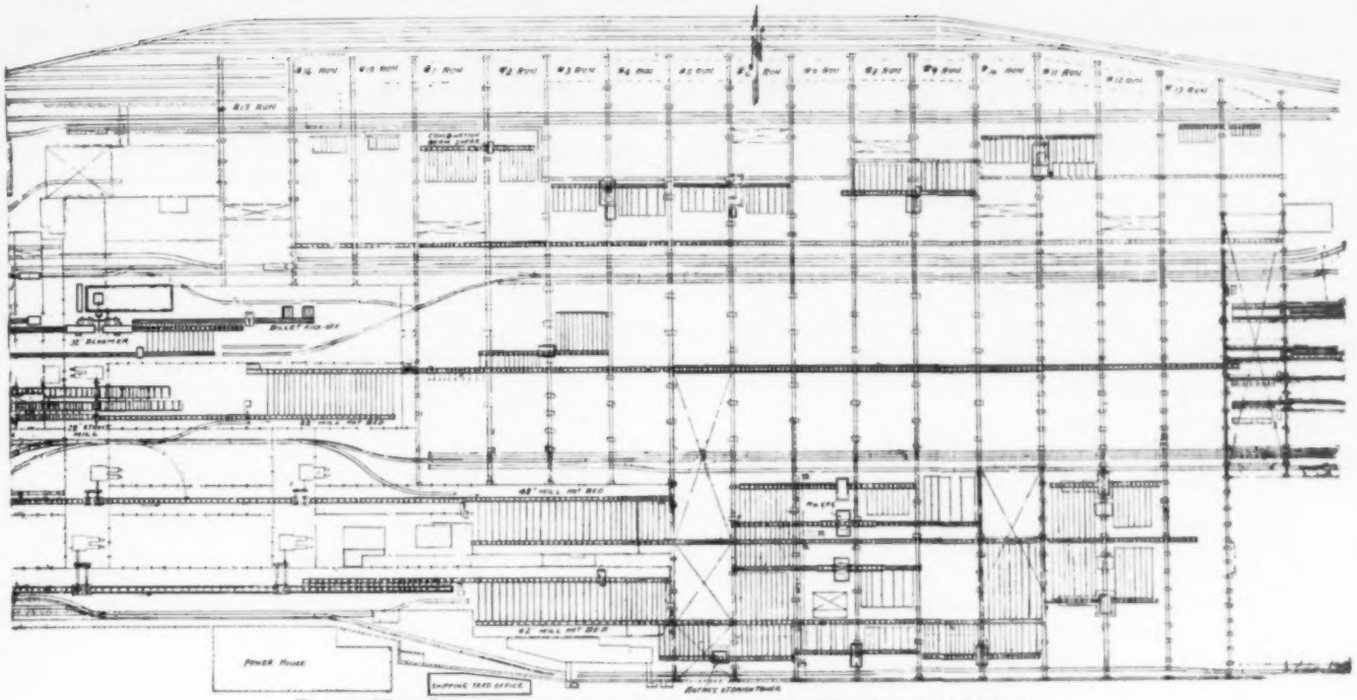


Figure 35 — Sketch shows proposed changes in shipping yard layout.

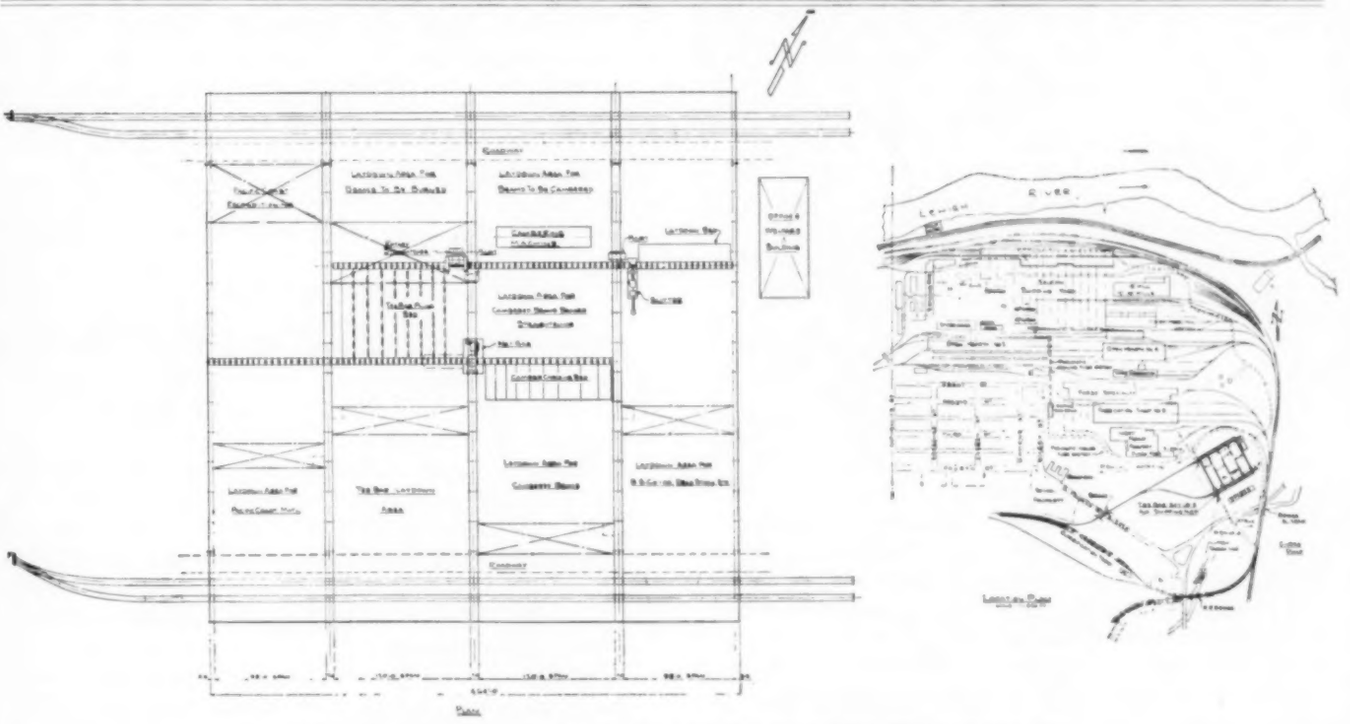


Figure 36 — Arrangement of Teebar setup in auxiliary shipping yard.

portion of the figure. This new combination actually provided a 180 per cent increase in capacity over the old mill.

The new 40-in. mill, shown on Figure 34, was planned as a combination mill which would alternate in rolling two slabs in tandem and then reduce an ingot for the 32-in. mill, which would then roll either a billet for the 12-in. and 18-in. mills or a bloom for the 28-in. mill, as required.

Slabs are sheared, stamped, and immediately transferred northward, which clears the production line to the 32-in. mill. They are then moved from a piler to transfer cars which deliver them to a new slab yard provided for shipping them west, thereby isolating them from the structural operation.

An existing 500-ton billet shear was relocated and facilities were added for loading billets on narrow-gage cars for transporting them to the 12-in. and 18-in. billet yard. A new 500-ton open-side shear was provided for the 28-in. standard mill product as well as two new 2-zone reheating furnaces for the 28-in. mill. Otherwise in this section, worn roller lines were replaced. Space is available beyond the 32-in. mill for the installation of a continuous billet mill if justified by future demands.

When making these changes, the 32-in. blooming

mill was placed in service before the old 40-in. blooming mill was removed, and rolled billets for the 12-in. and 18-in. mills, while the main source of supply was being replaced. Ingots by-passed the construction area by narrow-gage car and were transferred to the mill table by crane.

The only change in the 12 and 18-in. structural mill (shown on Figure 33) at the northeast end of the shipping yard was the erection of an additional billet yard runway and a new two-lane, two-zone reheating furnace to complete the desired increase in capacity of this product. The additional yard has a 20-ton double-trolley crane, and the new furnace is fed by a billet unscrambler.

STRUCTURAL FINISHING AND SHIPPING YARD

It was stated previously that conditions in the structural yard (Figure 35) were a major obstacle to be overcome in releasing the potential of the Grey mills for production of 60,000 additional tons of wide-flange per month. Briefly the conditions were as follows:

1. The five finishing mills feeding into this yard could not have their product diverted elsewhere without moving an entire mill.
2. The yard area was already highly congested and all material shipped was being double-handled many times after rolling.
3. The main yard was hemmed in on all sides and could not be expanded.

The only practical answer to this problem was a faster movement of steel from mill to customer and every change was designed to accomplish this.

In order to offset the loss in laydown space due to the installation of new equipment and to compensate for space taken by construction forces, a new auxiliary yard of four and one-half acres, which would finally account for 20 per cent of the total shipments was constructed approximately one-half mile from the main yard, and is shown on Figure 36. It consisted of four crane runways with one crane each. The outside runways have two 10-ton double-trolley cranes with 98-ft span and the inside runways have two 20-ton double-trolley cranes with 120-ft span. These runways are 445 ft long and are served with a truck-carrier roadway and two railroad tracks at each end. Some 40 rack-type railroad cars and four 22-ton straddle-type carriers were provided for transporting material to this yard. The Teebar slitter was moved from the 42-in. mill runout area to this yard and a new Teebar rotary straightener provided in line. The cambering machine was moved from the main yard and located in the auxiliary yard with an old 48-in. mill gag which was completely reconditioned. In this way, specialty operations such as cambering, slitting, and Teebar straightening were transferred and extra laydown space provided to relieve some of the congestion in the main yard.

The cold-cutting units are located along the north portion of the main yard, as shown on Figure 35, and a roller line and roadway were extended through this area, parallel to the railroad tracks, in order to facilitate the feeding of the cutting units and loading for final shipment, or transfer to the auxiliary yard.

One of the early equipment moves was to relocate a 48-in. mill gag from the hot bed runout roller line to a new location paralleling two other 48-in. mill gags, where the auxiliary yard had made it possible to clear space for the required transfer and assembly beds. Formerly this gag had been used to straighten a small percentage of this product in one axis only, as it left the hot bed, and now a bar could be manipulated and completely straightened by it. This constituted a gain in straightening equipment only after the old center gag was replaced by a new unit which is the largest gag type straightener ever built. It has a maximum anvil spread of 16 ft-0 in., and the oscillating head completes a 2-in. stroke at 33 cycles per minute. The anvils are equipped with air lifts, and beam turn-up and lowering rig are provided at the machine in addition to the old manipulators outside the building. A better job is done with this machine in removing sweeps on large sections that might otherwise result in loss of the bar.

The next series of moves that promised the most relief in straightening was the adding of straightening capacity back of the 42-in. mill. With only four gags back of this mill, production was curtailed on 85 per cent of the sections rolled even though sections were lifted off for straightening on future mill down shifts and also used all other available facilities.

An overhung type straightener with nine rolls was provided with capacity to straighten the product of this mill as fast as it could be rolled. The straightening speed ranges from 200 to 400 fpm depending on the section involved.

This machine was located at the south end of the No. 5-6 runways formerly occupied by No. 7 gag, for the following reasons: (1) it was off the runout line from the 42-in. mill and could be by-passed by the mill product if desired during roll changes, repairs, or the production of sections that could not be rotary straightened; (2) re-straight bars could be recirculated from the discharge bed and sent through the machine again if desired; (3) all gag assembly beds were also available for inspection and shipment of fast moving product from the rotary straightener. Related moves were placing No. 7 gag in the No. 11-12 run, relocation of office facilities, extension of the 42-in. hot bed for 30 per cent increased cooling area, and the installation of a second hot saw on the new bed to cut multiples and reduce handling as well as the load against cold-cutting units.

Further changes in streamlining these facilities was the relocation of No. 4 and No. 5 gags from the No. 10-11 runway area to the new locations shown. Additional asesembly beds are contemplated in the No. 9 and No. 11 runway areas for this product in order to improve flexibility. The railroad track at the bottom of Figure 35, was relocated between No. 8 and No. 13 runs to facilitate shipping to the trade or to the new auxiliary yard, thereby keeping a portion of this product out of the congested stocking, loading, and cold-cutting area to the north.

The relocation of these gags meant that a cold saw in this area had to be taken out of service. This loss was more than compensated for by the second hot saw on the 42-in. mill hot bed and the installation of a 600-ton combination beam, channel and angle shear in the north No. 1-2 run area. By changing heads, this shear becomes a coupon-type shear for wide-flange

beams up to BJ12, and capacity for experimenting in shearing larger sections, or a conventional angle shear for a maximum 8 x 8 x 1⅛-in. angle of silicon steel.

The 42-in. mill gag moves were followed by the rebuilding of the three original hot beds, and deepening of the pit area for more effective cooling This completed the changes which released the last bottleneck restricting the free flow of tonnage from this mill.

The extension of the 48-in. hot bed and rebuilding of the old portion of this bed are under way, as are track changes, roller lines, and other normal replacements. This also provides approximately 30 per cent increase in cooling area.

Changes in the structural yard to date enable us to straighten the regular product of each mill as fast as it can be rolled. Further flexibility is available in rolling top 42-in. mill sections on the 48-in. mill, and we contemplate providing a rotary straightener for this product as well as many of the regular 48-in. mill sections.

In this program, our bottlenecks are being relieved by modernizing, rebuilding, and streamlining for a free flow of fast moving material from mill to customer.

During the past year, most of the major changes have been made and for every advantage gained in new equipment, obstacles to production were naturally encountered. During this time total monthly shipping records were established and the mill group did an exceptionally good job in maintaining production during the construction program.

For these accomplishments, the engineering, construction, service, operating, and production groups deserve a great deal of credit for their detailed planning and full cooperation in coordinating the efforts of all concerned.

We are confident that our goal is within reach.

DISCUSSION

PRESENTED BY

E. C. PETERSON, Assistant to Vice President Engineering, Birdsboro Steel Foundry and Machine Co., Birdsboro, Pa.

J. A. BELL, Chief Engineer, Bethlehem Steel Co., Bethlehem, Pa.

R. W. COUCH, Superintendent Mills and Shipping Yard, Bethlehem Steel Co., Saucon Division, Bethlehem, Pa.

E. C. Peterson: We were privileged to furnish the 32-in. mill that went into this installation, with the complete construction drawings for all foundations, and I can verify Mr. Bell's comments as to the closeness of all clearances. It is important to have complete and accurate field measurements under these conditions. Mr. Bell's department furnished such information and as a result the installation went forward without serious mishap.

On the illustration for the slab piler in back of the 40-in. mill, I notice that the slabs run off the table and drop onto stationary cradles. I would like to ask if this type of slab piling causes bending of the slabs?

With regard to the rotary straightener for wide-flange beams, I would like to inquire as to the largest size of wide-flange beam that is straightened, and also as to whether satisfactory straightening is obtained above both axes of the beam. Is this straightening accomplished without distortion of the flange?

Referring now to the large combination beam shear that was shown, I would like to ask as to whether or not distortion of the flanges is noted in shearing of a wide-flange beam?

J. A. Bell: Regarding the slab piler causing any trouble, it has not given us any trouble to date. Some lighter slabs might bend slightly as they hit the bottom plate but lying there, its own weight brings it back to its original straightness.

In the beginning we had planned to put in a piler with automatic weighing but finally decided on the present set-up. It is a simple design; it does a good job. Why spend considerably more money for a piler that automatically drops the required amount to receive the next slab and be bothered with a possibility of a great deal of mechanical maintenance.

Insofar as the rotary straightener is concerned, it is designed for the 21-in. maximum beam. Mr. Peterson asks if satisfactory straightening is obtained about both axes of beam. The answer is yes, quite satisfactory. It is accomplished without any distortion of the flanges. However, it must be remembered that there is a limit to the width of flange that can be straightened on a rotary straightener. That is, you are limited in what you can put through the rotary straightener due to stresses set up in the webs. These stresses are governed by the center distances between rolls, and the loads necessary to straighten the vertical flanges are so great that, in most cases, it is too much for the lighter thickness of web, which results in tearing of the web from the flange.

In our particular case, we are able to straighten beams with a maximum of 8¼-in. width of flange, which as mentioned above is governed by our roll centers of 40-in.

R. W. Couch: This beam shear is adequately designed for cutting up a 4-in. flange and the shear is designed for 19 cycles per minute. The stroke is 12½ in. and provision is made for experimenting in cutting sections with more than a 4-in. flange. As soon as we can draw our breath a little bit and have time to experiment, we propose to do that. To date we have had so much steel back of this unit that we have not tried to do anything new with it.

It might be best to explain the action of the main shear knives as applied to this shear. Just before the shearing motion starts, side knives move in and clamp the flanges and provide support during the cut. A clean cut is obtained. An oil mist is sprayed on the large knife which lubricates it and prevents build up of metal on the surface. We hope we can do as well when we try shearing wider flanges, but we can see there would be a tendency for metal to pile up and possibly tear if we have a heavy and high flange.

What Mr. Bell says about the rotary straightener is correct; there we have not had a chance to do much experimenting, because of a backlog on straightening and we have had to use every available facility in order to keep ahead of the mill.

By W. H. KAHL, Combustion Engineer — Open Hearths, Inland Steel Co., East Chicago, Ind.

Application of Steam / Fuel Ratio Control to Open Hearth Operations

. . . . steam/fuel ratio equipment gives more uniform operation, more precise control, and improved protection . . . . disadvantages are higher initial cost, additional required accessory equipment, and the more highly skilled personnel required . . . .

▲ THE old questions of "Why do we need this and what will it do for us?" are almost certain to arise when the subject matter of this paper is proposed to open hearth management. Indeed, the answers to the questions may be embarrassingly difficult to supply in one short, overwhelming burst that overcomes all further discussion.

More or less recent developments in the fields of atomizing liquid fuels with natural gas or other gaseous fuels, and of course compressed air, seem far more desirable than using the old standby of steam, from the theoretical point of view. It is not the intent of the writer to discuss the merits of the various atomizing agents now in use or potentially usable, but rather to discuss some of the factors we at Inland considered before installing steam/fuel ratio controls in our newest shop. With the lion's share of atomization being accomplished with steam throughout the industry, it is hoped that some benefit may be gained by a review of past and present experiences.

The terrific production increase from existing facilities during and following World War II is a well known story. New producing units constructed enjoyed the benefits of valuable experience gained during the stress of wartime production demands, and it is interesting and satisfying to see that instrumentation and control have certainly moved into the heart of the operation. In the final analysis, any piece of instrumentation or control must survive or fall on its ultimate acceptance and use by operating personnel, all other factors being favorable. A modern panel board including multi-fuel Btu summarization, fuel/air ratio control, steam/fuel ratio control, automatic draft regulation, checker or flue temperature recorders, roof temperature recorders, and other miscellaneous equipment, represents a tremendous step over a relatively short period of time, from a couple of oil shut off valves, a three-way steam valve, the air saucers and a stack damper winch that was standard equipment for an open hearth furnace.

Basic piping layouts remain the same, with valving and positioning of valves varying somewhat, but generally performing the same function of supplying fuel and the atomizing medium on alternate cycles to the furnace.

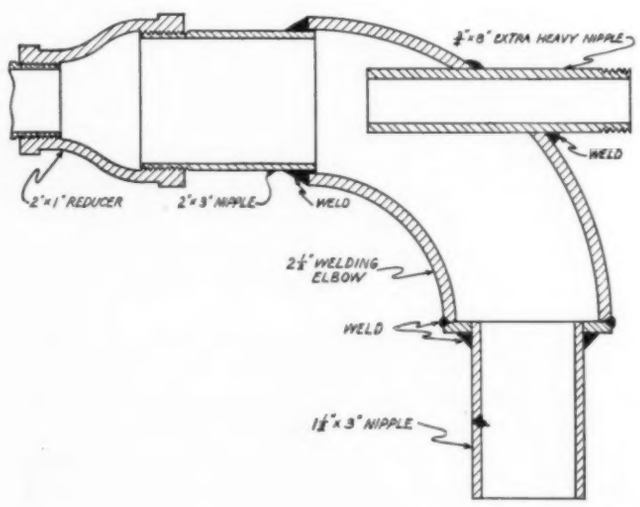
In a straight manually operated steam section, the manifold at the reversing stand is usually supplied from a controlled pressure header, with an alternate source, or two if possible. Either a three-way valve or individual shut off valves are provided in the manifold for reversing steam end to end. A pressure gage in each furnace line indicates the pressure on the end in service and serves as a rough guide to the operator as to his steam input.

High among the advantages of this system must be listed initial cost plus simplicity and reliability of operation. Using the mighty word "if" the system is properly sized and insulated, balanced end to end piping and bends are maintained, mixer or atomizer conditions remain constant as well as the burner, and burner tip, and the operator religiously follows his specified pressure gage patterns, this system will give excellent service.

Any of the previous conditions can of course be viewed with a critical eye, since any one of them can cause extreme variation in actual steam flow delivered for atomization and in turn seriously affect furnace performance.

Sharply increased hourly Btu inputs through old existing systems usually results in such common complaints as steam and oil bucking each other at the

Figure 1 — This gun-type atomizer is used by Inland Steel Co.



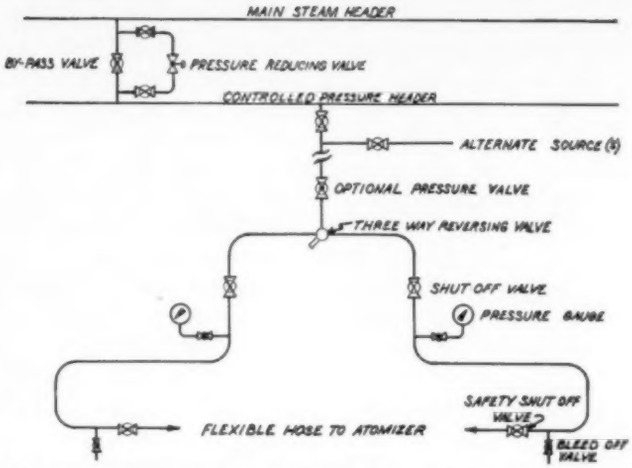


Figure 2 — Schematic diagram shows piping of manual steam section.

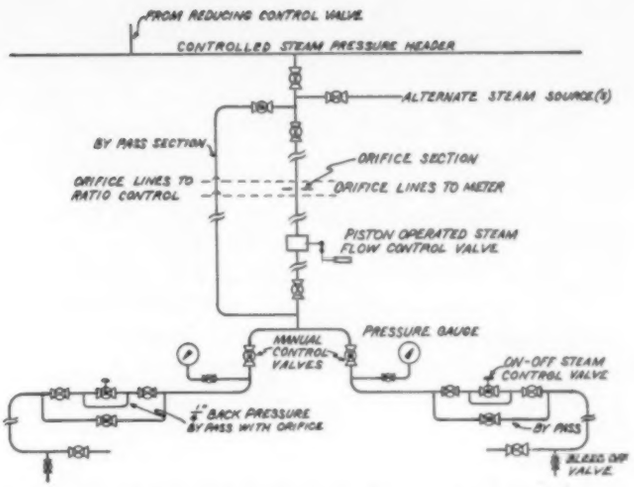


Figure 3 — Schematic diagram shows piping for steam ratio section.

mixer, different end to end oil flow with the same steam pressure on the gages, or "dead" flames due to lack of sufficient steam for atomization, each of which calls for checking and corrective action by the fuel departments.

Such problems were common in our No. 2 Shop as heat sizes moved from 165 tons to 200 tons per furnace. Pressure increases on our circulating oil loop plus the installation of differential oil flow controllers generally smoothed out the oil problem. Increasing sectionalized steam header pressures gradually until we reached main line pressures left us still in short supply on steam for atomization at maximum fuel input. Fortunately, Inland's oxygen program coincided with the final tonnage increase, and by using flame enrichment oxygen as a supplemental combustion aid, satisfactory furnace operation could be maintained during meltdown firing cycles.

With this background, a determined approach was made to provide a completely flexible and positive control over steam input in our new shop. Bunker "C" oil is the only fuel used for production in this shop, and our automatic oil control section therefore can readily be tied into air and steam control. Positive displacement meters driving a pneumatic signal sending device are used to load reaction diaphragms on both the air and steam ratio controls.

Each of the four furnaces is fed steam from a controlled pressure header section which in turn is supplied from the collecting main off the waste heat boilers. Surplus steam is carried off for mill use. A measuring orifice section designed for 5,000 lb per hour at 200 psig and 560 F is installed in the basement or cellar. The controlled pressure header is a 6-in. pipe, and the measuring orifice section is set in a 3-in. pipe. Immediately after the measuring section, one takeoff feed to the manual station is placed. Next comes a pipe reduction to 2-in. which is carried on through in size to the furnace ends. A 2-in. piston operated steam flow control valve, actuated by the steam/fuel ratio regulator signal is next in line. A 2-in. feed to each furnace end follows the flow control valve and in each line a 2-in. type diaphragm valve for reversing control is located. After the reversing valves, the feed lines from the manual station are tied into the system, and this completes the piping arrangements to the furnace ends.

A special 1½-in. flexible hose connects between the piping and atomizer which is located on the end of the burner.

The atomizer is a very simple gun type arrangement made by ourselves. We have standardized on a 2½-in. welding elbow into which a nipple is inserted parallel with one end of the elbow. The discharge tip is centered in the ring area formed by the end of the elbow, and terminates one inch back from the face. A 2-in. threaded nipple is welded onto the discharge end of the mixer and a 2-in. to 1-in. reducing coupling, nipple and union gives us the burner connection. The burner tubes are 1-in. standard pipe with a nominal inside diam of 1.049 in. and are 8 ft 10 in. in length.

Steam enters the atomizer at the bottom of the gun through a 1½-in. nipple welded to the elbow, picks up the discharged oil stream in what we assume is a turbulent action caused by the projecting oil nipple plus discharge restrictions and passes on out the burner tube.

The above atomizer was developed in the process of placing the steam/fuel ratio control in automatic operation through its full operating range of 0 to 6.33 lb steam per gallon of oil fired. Although a design specification of 650 gphr had been set for the furnaces, an increase to 800 gphr was made almost from the start. With 1,000 gphr oil flow recorders, this posed no problem from the oil end. However, the initial flexible steam hoses, atomizers and burners were found undersized to handle the steam inputs at these flows. With 800 gphr and a desired setting of 5 lb steam per gal of oil fired, we were able to deliver only 3,000 lb steam per hr instead of the 4,000 lb called for. Step by step corrections were made until the system today is substantially as outlined above.

The basic function of the steam ratio regulator is to supply a constant ratio of steam in pounds to oil per gallon fired. In automatic operation, the operator sets in his desired ratio setting of steam for whatever stage of the heat he may be in. For example, a setting of 4 on the dial will give him 4 lb of steam for each gal of oil fired, regardless of the variation he may make in oil input. Dual taps are used at the steam orifice sec-

tion, one set going to the steam meter, the second set to the measuring diaphragm in the ratio control. The amount of steam flowing is thus measured in two different devices, giving a good cross check on each unit's performance. A mechanical linkage arrangement between the measuring diaphragm is bucked against the pneumatic signal from the oil flow signal sending device. Any imbalance between the steam and oil signals results in immediate hydraulic action on the 2-in. steam flow control valve until balance is restored.

Another feature incorporated in the steam ratio control is solenoid valves tied into the automatic reversal system that are energized at reversal and drive the steam flow control valve to its wide open position. Using check and throttle valves on the 2-in. steam reversing valves enables us to close open valves slowly, and open quickly the valve to go into service. The additional steam input gives a good purge to the burner going off and makes for clean, sharp reversals throughout the heat cycle. We also feel definite benefits in burner tip life have been realized with this system. It probably should be stated that the same functions are performed simultaneously by the air and draft controls during reversal.

The importance of this feature becomes more apparent when reversal is made by high temperature limit through the checker temperature recorder and may occur as frequently as every three minutes until the operator can afford to cool his system down, depending on his heat conditions.

During the period of bringing all control components into full automatic operation in the shop, considerable testing was carried out as various changes were made to meet the desired standards. Once satisfactory steam control was attained, a series of heats were made utilizing various steam ratio settings with a constant oil input during the meltdown period. Tests were started at 4 lb per gallon and carried upscale in two half pound steps to 5 lb per gallon. A total of ten heats were melted under each setting. A study of the results showed a decrease in finish charge to start hot metal of roughly thirty minutes in favor of the 5-lb setting over the 4-lb. Charging times during this period averaged around one hour and thirty minutes on a 52 per cent hot metal practice.

Some interesting comparison data is presented in Table I to show the effect of the above by typical monthly performance.

TABLE I

	Jan. 1953	Jan. 1954	Jan. 1955	June 1955	1st 6 mos. 1955
Time, charge-to-tap	11.29	9.57	9.47	9.48	9.64
Time, tap-to-tap	12.51	11.04	10.42	10.45	10.61
Tons per hr—charge-to-tap	24.61	28.05	30.40	30.68	30.09
Tons per hr—tap-to-tap	22.00	25.21	27.63	27.83	27.34
Million Btu per ton	3.358	2.904	3.314	3.527	3.416
Per cent hot metal	52.5	41.9	39.9	40.4	39.9

Per cent cold iron	0.2
Yield	88.5
Average heat size, tons	290.1
Per cent limestone	5.8
Per cent burnt lime	0.5

As is true in most cases where open hearth data is concerned, it should not be concluded that any single item, in this case, steam/fuel ratio control is the sole agent responsible. It will have been noted that the furnace went from flush to scrap practice, with an increase of approximately thirty minutes in charging time. At the same time, present fuel oil in use is a special low sulphur product purchased at a premium price. This oil averages between 0.6 and 0.7 per cent sulphur as compared to our normal open hearth fuel of 1.14 per cent sulphur. This factor allows a lighter limestone burden of approximately 1.8 per cent which means improved heat time after metal addition.

Approximately 95 per cent of this shop's product is 0.10 per cent carbon and under, and about 26 per cent of the product is 0.030 per cent sulphur and under, the remainder being between 0.030 and 0.035 per cent sulphur. Ladle sulphurs on all specifications consistently average between 0.027 and 0.028 per cent.

Our original deliveries of low sulphur oil contained an abrasive material in suspension that literally took oil meters apart faster than they could be maintained. This condition naturally led to much confusion control wise, and also led to heavier furnace abuse since the operating personnel tend to rely on their equipment to tell the truth. Fortunately, this condition has been alleviated considerably through present supply sources and we are once again within speaking distance of inventory figures.

It must be borne in mind that operating personnel in this shop were absolutely unfamiliar with not only the entire control system, but with a large furnace as well. Any normal development would lead to improved performance as experience was gained by these people in their daily routines. The ready acceptance and use of the steam section which dealt entirely in flow rather than in pressure was most gratifying. That it is being utilized to the best advantage to the limit of our limited knowledge is best reflected in results obtained to date. It is within this same framework of results that we justify the use of steam in quantity for melting. Ready duplication of steam ratios from three to four pounds, depending on heat requirements, day in and out, for the remainder of the heat gives operating personnel concise, fingertip control over a most important variable, otherwise potentially a question mark as to what goes on.

Should sudden, always looked for developments in atomizers and burner designs employing steam make possible a sharp reduction in steam input with comparable results, we naturally could and would make the shift with only a reeducation of values for furnace personnel necessary.

With the criteria available from our new shop, permission to add steam ratio to four completely rebuilt furnaces in No. 2 shop was granted. Again, a completely new instrument panel was installed to accompany the conversion of the old 145-ton furnaces to 200-ton units. At the conclusion of this program, a separate program of replacing all old, existing steam lines for the furnaces in the No. 2 shop with new 2-in. lines was started.

In the latter program, all installations are made with

provision for addition of ratio control as time and equipment is made available.

Instrumentation on the rebuilt furnaces in No. 2 shop includes automatic reversal, total Btu summarization, fuel/air ratio, steam/fuel ratio, coke oven gas control and the usual miscellaneous recorders and indicators.

Fuel oil is the base load for the summarization equipment with coke oven gas the supplemental fuel on an "available" basis. Total heat input is set through a Btu dial, which through its electronic amplifier-summarizer positions a motor-driven, differential oil flow control valve, by means of balancing associated slidewire voltages. If coke oven gas is added to the furnace, another electrical voltage unbalances the summarizing network and the oil valve is driven closed until oil flow and gas flow added together on a Btu basis by voltages match the desired input setting.

The fuel/air ratio control is fed the same signal as Btu demand and functions in the same fashion as above, supplying air dependent on its ratio setting in relation to total Btu input.

The steam/fuel ratio control receives its voltage signal of Btu demand only through the liquid fuel section of the network. Again, ratio to this signal can be varied from 0 to 6 lb of steam per gallon of oil.

Outstanding advantages of this system in the writer's opinion include:

1. The complete flexibility of all control components.
2. The ability, with only minor changes, to completely switch base loading from oil to gas if necessary.
3. Precision control of all furnace inputs gives operating personnel day to day results readily duplicated as conditions require.

With respect to the steam ratio section, the general data presented for our new shop applies to the rebuilt furnaces, as well as those equipped with the new steam lines and being operated as a straight manual section. From personal observation, it is the author's firm conviction that while we have materially boosted our operation productionwise through the new steam lines, a tendency towards over use of steam through the new manually operated steam section during the periods following hot metal addition to tap is perhaps natural, although definitely undesirable.

In summation, the author has attempted to point out the experiences at Inland with steam/fuel ratio equipment. Among the advantages we have found are:

1. Reproducibility of desired conditions day after day.
2. Reduced meltdown time through increased steam inputs carefully metered and controlled.
3. Improved refining time through precise ratio control of atomizing steam as determined by the operator and supervision.
4. Improvement in overall furnace abuse by helping place responsibility on the operator through elimination of guesswork pertaining to important variables.
5. Improved reversal cycles with cleaner ignition and reduced carry over.
6. Intangibles, such as operating morale which is decidedly important in today's production pace with the specification limitations imposed.

Disadvantages noted are:

1. Initial cost of equipment and installation.
2. The need for developing suitable accessory equipment to make the units completely functional, and to develop optimum base operating practices to suit the individual conditions.
3. Time must be spent to train operating personnel to utilize the equipment to best advantage.
4. Increases the need for and the work load of trained technicians to service and maintain equipment at top performance levels.

DISCUSSION

PRESENTED BY

F. S. SWANEY, Combustion Engineer, Pittsburgh Works, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

W. H. KAHL, Combustion Engineer — Open Hearths, Inland Steel Co., East Chicago, Ind.

G. H. KRAPF, Division Superintendent — Power Production, United States Steel Corp., South Chicago, Illinois.

H. V. FLAGG, Combustion Engineer, Armco Steel Corp., Middletown, Ohio.

E. T. W. BAILEY, Chief Combustion Engineer, Steel Co. of Canada Ltd., Hamilton, Ontario, Canada.

F. S. Swaney: The open hearth process is one of the most complicated in the steel industry. These complications arise from the fact that the process is essentially a series of chemical reactions carried out at extremely high temperatures. The attainment of the high temperatures required makes mandatory the use of a regenerative firing system. This in turn, doubles the number of burners and their attendant piping and increases the complexity of the waste gas system. In addition, complications arise from reversal of furnace firing. Also, high production rates demand that the furnace be operated at or near the safe, maximum temperature for the materials involved. The chemical reactions, taking place as they do in the same chamber as the combustion process, interfere with, or partake in this process to an extent which is difficult to determine.

Thus, it can be seen, the operation of an open hearth furnace consists of controlling, at optimum conditions a large number of interrelated variables.

Some years ago, the detection and control of all these variables was one of the duties of the furnace operator. Since his only aids were a few pressure gages and possibly a clock, he more or less "flew by the seat of his pants" and we can safely assume that optimum conditions were not maintained at all times.

Over a period of time, however, more and more of the variables involved were measured and either presented to the operator for his control, or put on an automatic control basis. Thus fuels and steam are metered and controlled, and furnace pressure, roof temperature and checker temperature are all measured and in some cases, controlled. Combustion air flow was measured and possibly ratioed to fuel input. The mechanical

operation of furnace reversal was made entirely automatic. Further aid was given the operator with the successful application of bath temperature measurment.

Thus it can be seen, almost all the important variables in furnace operations have been measured and either controlled automatically or made readily adjustable by the operator.

One of the few variables generally left uncontrolled today is the subject of the paper we have just heard. We ourselves, have had no experience with fuel/steam ratio control but we do believe that there is a definite need for some such device. Our No. 4 shop operates on a controlled steam pressure just ahead of the atomizer, this pressure being remotely set by the furnace operator. It has been our experience that many times the furnace will be operated for extended periods of time with no changes in steam flow, or that changes in fuel flow will not be followed with similar changes in steam flow. Also, changes in flame characteristics that are obtained by varying the fuel/steam ratio are not used to full advantage during different stages of the heat.

In view of the above practices, we are at the present time in the process of installing a fuel/steam ratio control on one of our furnaces in order to see if we can improve our operation. We believe that it will probably be quite difficult to justify such an installation on a dollars and cents basis, but we also think the idea is theoretically sound and will permit control of another open hearth variable.

We are interested in the following four points, if Mr. Kahl would care to elaborate on them:

1. How often are you troubled with your fuel/steam going out of control due to plugged burner tips?
2. Do you have a more or less fixed schedule on both fuel and fuel/steam ratio? If so, what is it?
3. You mention conducting tests on fuel/steam ratios from 4 to 5 lb per gal. Have you gone higher than 5 and if so, with what results?
4. What pressure on both oil and steam is required ahead of the atomizer for you to fire 800 gphr of oil and 4000 lb per hr of steam?

W. H. Kahl: Inquiry is made as to how often we experience plugged burner tips. I can say in answer to that, that we have gone as long as two months without ever having an oil burner out of the water-cooled shell. Perhaps we have gone longer.

Again, we have had to change them in the same day and it is a problem. There is the human element, inasmuch as a great deal depends from our experience, on where the pipefitter sets the burner when he makes the final adjustment after he has had the burner out of the furnace for cleaning or replacement. We ask our men in our particular installations to keep the tip of the burner pipe about one-half inch back inside the water-cooled shell that it slides through.

We have found any further distance back inside the tube gives us a dirty burner, and by the same token, anything closer to the tip or beyond the protecting shell immediately takes us into trouble.

The second point was, do we have a maximum firing schedule? We have no firing schedule other than a maximum amount of fuel that may be used during the meltdown cycle. We have three furnaces that are allowed 800 gphr during the meltdown. The fourth furnace in this particular shop, which is an extended hearth job, is allowed 900 gphr during the meltdown. Those are our only stipulations. Routine firing is strictly at the discretion of the furnace operator.

Inquiry was also made as to whether we have run any tests at five pounds of steam per gallon of oil fired and higher. I can answer that tentatively this way. Some tests at six pounds of steam per gallon of oil were conducted. It works very well on a very bulky, light charge in the furnace where you can concentrate the charge in the ends and leave the middle open. However, under normal charging conditions where you want to spread the scrap burden over the entire hearth, it gives you too intense and too short a flame to get the sort of coverage normally desired across the hearth.

We propose further experiments along this line. Where it will lead, I am in no position to say.

The fourth question was on pressures at the atomizer for 800 gphr of oil and 4,000 lb per hr of steam. Under those firing conditions—and these pressure readings are taken approximately six in. ahead of the atomizer, which I trust will be satisfactory, we have 165 psi oil pressure and around 175 psi steam pressure. I may be plus or minus a few pounds, but I believe this is fairly close.

H. V. Flagg: I would like to open my discussion of Mr. Kahl's paper with a sincere compliment to the author and his associate, both in staff and operating, for their practical and sensible approach to this important subject. It is refreshing to find in this paper that steam is considered as a helpful agent rather than as an adverse influence, and that emphasis is laid on the need for plentiful supply of steam at high temperature, rather than some impractical and usually costly scheme for elimination of steam.

The oil burning installation described by Mr. Kahl certainly reduces the question to elementals, a measured amount of oil and a measured amount of steam poured into a pot and the mixture of oil and vapor delivered into the furnace through a piece of standard pipe. Apparently no thought was given to such highly theoretical considerations as jet momentum, momentum flux, free-jet length, nozzle profile, etc., which we find discussed at length in current literature—all they tried to do was to get oil and steam vapor just as hot as they reasonably could within the limitations of heat available and valves and piping, with enough pressure behind the mixture to produce a jet which would generate a flame of proper intensity and shape across the hearth.

The steam conditions quoted, 200 psi and 560 F, indicate that some unusual steps have been taken to preheat steam since the temperature of saturated steam at 200 psi is 388 F. It might be interesting to make a somewhat different analysis of the oil-steam jet mixture than is usually found. Consider fuel oil to weigh 8.25 lb per gal, to be delivered to the burner at 190 F and 200 psi and specific heat to be 0.44. Consider steam to have 1295 Btu per pound, at 200 psi, and 560 F.

The amount of steam used per pound of fuel and the amount of heat in that steam are as follows:

Lb steam per gal oil	4	4.5	5
Lb steam per lb oil	0.485	0.545	0.606
Btu in steam per lb oil	628	705	784

When steam and oil are mixed together, the oil is immediately heated to the temperature to which the steam is reduced by loss of heat to the oil. The pressure and specific volume of the steam-oil mixture are changed at the same time to the conditions of steam at the reduced temperature. The effect of the volume of oil at mixture temperature on the oil-steam mixture volume is so small that it is ignored.

The mixture temperatures and pressures for the conditions of heat shown above are as follows:

Lb steam per gal oil	4	4.5	5
Mixture temperatures, F	312	321	337
Mixture pressure, psi	65	76	99

These figures show that the pressure of the mixture pushing it through the burner pipe is far below the pressure available at the entrance to the mixer. If the steam temperature were to be increased to 650 F for the same conditions, it would be found that the superheat in 5 lb of steam per gal of oil would be just sufficient to heat the oil to the saturated steam condition of 200 psi and 388 F. It does not follow that this condition is either necessary or desirable, since the factors of fuel flow, hearth length, and burner pipe size necessary for proper flame coverage must be taken into consideration. The conclusion is inescapable, however, that restriction of the amount of steam soon reduces the energy potential behind the oil-steam mixture to a point where control of flame development is lost. This point was emphasized by Mr. Kahl when he made the point that adequate steam piping is essential.

The condition set up by Mr. Kahl's paper brings out another interesting point in connection with volumes and burner pipe velocities. Referring back to the mixture steam conditions, it is found that the specific volumes for 65 psi, 76 psi, and 99 psi steam are relatively 5.48, 4.85, and 3.92 cu ft per lb. This means that the condition of lowest pressure for a given fuel oil input must push the largest volume of fluid through the burner pipe. The fluid velocities leaving a standard 1-in. pipe for 650 gpm for 4 lb, 4½ lb, and 5 lb steam, work out respectively to 661, 658, and 591 fps. Similar calculations for lower steam consumption per gallon show that the temperatures and pressures of the mixture are respectively 299 F and 51 psi for 3½ lb steam per gallon oil, and 287 F and 40 psi for 3 lb per gal. The tip velocities for the lower steam quantities work out to 707 fps for 3½ lb and 706 fps for 3 lb, which indicates that the higher specific volume is balanced by the decreased mass. The actual result would be that with decreasing steam and heat, less and less pressure is left to push a constant volume of fluid through the burner pipe. When the point is reached where the mixture pressure is insufficient, condensation will occur until the release of latent heat and the reduction of volume combine to bring about a balance between mixture pressure and burner pipe resistance. Such a combination of pressure and temperature limitation undoubtedly accounts for the black core seen in many open hearth flames.

Mr. Kahl's pipe-tee atomizer should not be left without some mention. Every discussion of the subject of atomizers that I can recall has wound up with about the same conclusion, namely, that complications in atomizer design merely increased the cost without any substantial improvement in performance. I would like to throw one suggestion into the pot, however, for it seems to me that an atomizer so constructed that the steam adjustment could be made at the atomizer in response to a ratio control such as Mr. Kahl has described, would take us one step further on the road to proper control of flame development.

E. T. W. Bailey: Mr. Kahl's excellent description of steam/fuel ratio controls applied to open hearth furnaces covering economic benefits, design, operational advantages and results, generally coincides with our own experiences.

The Steel Company of Canada, Ltd., adopted steam/fuel ratio control feature as a part of the overall control system for their four 275-ton furnaces, started late in 1952. Since that time, all furnaces have been equipped.

In our case we list one additional advantage which may be of interest. During the melting period, coke oven gas is burnt along with fuel oil. The gas volume is, however, not constant, but varies in accordance with plant availability. This variation is automatically compensated for by adding or subtracting from the accompanying oil flow, to hold a constant calorific input to the furnace. It was found that changes in gas flow changed the flame length and, in order to reduce this, extra steam is added at the approximate rate of 2 lb per 280 cu ft of gas. The ability to automatically proportion steam to gas, as well as oil had been incorporated into the original control design. Considerable careful test work had to be done to arrive at the optimum amount. Now it is common to see steam added at the rate of 6 lb per gal oil, concurrently with 2 lb of steam, per 280 cu ft of coke oven gas (the approximate equivalent of one gal of oil on the net Btu basis).

G. H. Krapf: I was interested in the remarks on proportioning steam to gas as well as to the oil in a combination fired furnace, because we have found from our experience that there is something to the idea. Furnaces, especially during meltdown, seem to require the momentum that is furnished by the steam in the burner to properly entrain the combustion air into the fuel stream to obtain a short flame and high flame temperature. This means that steam is being ratioed on the total fuel fired, instead of being ratioed to the liquid fuel fired in such furnaces.

H. V. Flagg: I wonder if anybody still thinks that steam is a bad agent which should be barred from open hearth furnaces? That has been quite a controversial subject in recent years. I was interested in Mr. Krapf's and Mr. Bailey's remarks on proportioning steam to gas as well as to oil, and should like to learn the reasoning behind them. The important point is that an ample supply of heat is vital.

Selection of Solvents

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▲ DURING the last decade, and continuing now at an even faster pace, the iron and steel industry has undertaken both expansion and modernization of its plants and equipment on a scale that taxes the imagination. In keeping with the utilization of new and larger equipment, there has been the realization that methods and standards for operating supplies must be up-graded to gain maximum efficiency from the improved plant of today.

A large part of the new equipment in use today is built to achieve faster and more accurately controlled production and, by comparison to older equipment, is constructed to closer tolerance standards and higher power loads. This situation has created a form of obsolescence which applies to the standards of selection for solvents required to maintain and operate the plant and tools of iron and steel production. Stated briefly, more efficient machinery requires more efficient kinds of cleaning solvents to maintain it.

The author has been privileged to observe both the processes of selection and the uses of cleaning solvents in a large number of shops and plants in many phases of the iron and steel industry. Methods of selection range from none at all to procedures so complex as to defeat their purpose entirely. In some of the larger steel companies, there is a centralized maintenance function and, where this function operates in harmony with both the safety and medical-hygiene units, there has been notable improvement in cleaning efficiency as well as in accident experience. Such a happy state of affairs, however, appears to be the exception rather than the rule. There are sound reasons for this apparent paradox which may be found by an analogous examination of part of the history of the oil industry.

Lubrication engineering now a highly respected and necessary profession, became a specialized function of the engineering profession as a direct result of improvements and new invention in mechanical and electrical equipment in the 1915-1925 era. High rates of failure in the more precise equipment of that era made necessary the study of better methods of lubrication and the subsequent development of a host of special-property lubricants to keep equipment operating at rated efficiency levels. The major oil producers recognized this fact and devoted appropriate research and specialized training to personnel to service this market. Independent specialists and chemical companies have made their contributions as well.

It is the opinion of the author that we have reached another phase change in our technology, where the tolerances and sensitivities of materials and surfaces have created a similar situation which may bring about recognition of the need for solvent engineering on a professional status in industry.

At this point, the analogy becomes less clear, because of fundamental differences in physical properties and uses of solvents as compared to lubricants. While lubricants represent a degree of fire hazard and are, as well, a causative of dermatitis, such hazards are relatively minor as compared to those presented by solvents.

In the iron and steel industry, the selection and control of lubricants is generally the function of the lubrication engineer. By comparison, the selection and control of cleaning solvents, whose capacity potential for causing death and destruction are much greater, may be in the hands of almost anyone from the purchasing department to the lead-man in the shop which uses the solvents. In each case the final selection of the solvent, if it will perform its cleaning job reasonably well, is made largely from the functional viewpoint of the one who makes the final decision, whether it be the buyer seeking price, a favored vendor, or because a workman prefers the odor of 'A' versus 'B'. Yet none should be criticized because each is performing his function to the best of his ability.

The same factors which led to the development of so many varieties and specializations of lubricants have served to bring new solvents, by adaptation and creation, into the iron and steel industry. The growth of the industry, both in size of physical plant and in numbers employed, has served also to increase the volume of solvents used, as well as their number and variety. The constant search for improvement in efficiency of solvent performance has combined with previously mentioned factors to bring about a form of industrial

and Control of Hazards

The primary need in handling solvents safely is better knowledge and training in their selection and use . . . . selection should be made by a team representing engineering, purchasing, fire control, safety and hygiene . . . . simple but effective standards for control should be established . . . .

indigestion with the result that some seek a panacea and others, the universal solvent. Such thinking, if carried into logical conclusions, would demand that all steels be surface coated to prevent oxidation, or that only one kind of steel be produced.

The solution to the problem of "Solvents Indigestion" lies in the recognition of the basic nature of solvents, their properties, potentials and the special techniques needed to evaluate them and to control their use. Such recognition must imply an admission that there are few men, if any, who possess sufficient knowledge to assess such products from all points of view. Such appraisal is more properly a team function. It follows that the members of the team must respect the specialized knowledge and skill of the others and accept the fact of their own shortcomings in areas outside of those for which they are trained.

In considering a solvent for a given use, it is obvious that the solvent must dissolve unwanted matter of a given kind from a surface. As a rule there is a fairly wide choice among those solvents which will take unwanted matter into solution. The mechanical factors to be weighed at this point are simple. They are: solubility, efficiency effects on the surfaces to be cleaned, adaptability to the proposed method of cleaning, and the quality level of performance that is desired. The decision in this area should be made by the operating personnel directly responsible for the work to be done.

Since all solvents are toxic (water excepted) and most solvent vapors will propagate or support combustion, two members must be added to the team whose special knowledge is essential to the process of selection and control. These are the fire marshal and the industrial hygienist. These members must assess the physical and chemical properties of the proposed solvents to determine the nature of risks involved, to men as well as machines, with due regard to the method of application and the area in which the solvent will be used. Not only the immediate area of use is involved, but adjacent operational areas must be considered as well.

The decisions of these men will serve to reduce the number of candidate solvents to a few whose potential hazards are amenable to control within the framework of existing facilities. Inasmuch as quality control, not only of solvents purchased, but of products produced, must be maintained, the team should include representation from the engineering staff and the laboratory, whose function is to verify physical and chemical properties of the solvents and their relationship, good or bad, with plant processes.

This group, functioning in harmony, can draw a clear picture of the desired solvent, examine the offerings and narrow the choice of satisfactory materials to the point where the purchasing department can function most efficiently in the organization interests. The final member of the team is the safety engineer, who, with the cooperation of all, must see that the solvent is used in the manner and for the purpose it was selected. He has the job of selling the product and hazard control measures to the men who use solvents. He, therefore, must be informed completely of the process of selection and the reasons for selection.

In recent years the recognition of the fact that solvents are toxic has been growing, but full comprehension of the insidious nature of the effects of long exposure to many solvents is still largely confined to industrial medical and hygiene specialists. Fire, since it is visible and dramatic, is a hazard more universally known, hence the control measures to prevent fire are accepted more readily as are their methods of enforcement. The subject of physiological response to chemical exposure has produced papers and volumes of untold quantity. Practically all of the literature is generally incomprehensible to the layman who lacks specific medical training. Since man tends to suspect and reject that which he does not understand, the institution of toxic hazard control measures presents a practical problem which can only be resolved by a planned program of education to produce the cooperation that is necessary to prevent men from disabling or killing themselves and their associates.

It was the intent of this author to make reference to some standard text which, in tabular form, would provide ready comparison of significant properties of solvents as cleaning agents. This proved to be impractical since the figures for properties of solvents re-

viewed were presented on bases and systems of wide variation, depending upon the purpose and industry served. For this reason, the writer has made an attempt at interpolation of product data from a number of sources to arrive at a common denominator for more easy comparative values for the solvents most widely used in the iron and steel industry (Table I).

Since there also is variance in the properties of specific products offered by producers, the table endeavors only to show the major range of such variance for each type of solvent given. In a few instances, certain of the values were not subject to interpolation, hence were omitted. In all cases, drying time was factored on a comparative basis with carbon tetrachloride as 1.0 because of the general familiarity with the speed with which this solvent dries. There is no attempt to cover all the solvents used in the industry but, rather, to draw a broad picture of the principal types encountered.

The five points of data are those which, in the writer's opinion, must be considered in relation to each other in the selection process of a solvent for a given kind and area of work. The author has found aniline point to be more accurate than Kauri butanol, as a measure of grease-cutting ability, although both have value. Drying time, or volatility, weighs heavily since it affects cleaning speed, corrosion factors, fire and health hazards. Flash points should be considered in relationship to volatility as well as with regard to the proposed manner of use and the area of use of the solvent.

Maximum allowable concentration in parts per million (ppm) (volume) in air is a figure which has been subject to a great deal of abuse and misinterpretation. The figure represents an opinion of a qualified group of specialists as to the maximum safe level of tolerance to given solvent vapors of the average workman for an eight-hour day, five days per week. The assumption that this is a safe limit for all workmen under all conditions is fallacious, since the ability of a person to endure a hostile vapor is individual and may vary with state of health or even state of mind. The effects of exposure may be rapid and dramatic, or insidious and slow. In either event the economic loss is substantial. The need for coordination of the operating function with hygiene and safety functions cannot be stressed too greatly.

The five items of data used in Table I are by no means the only criteria by which suitable solvents should be judged. They are, however, a set of values which may be used initially to narrow the group of available solvents into manageable proportions. With this accomplished, the solvents remaining to be considered may be examined then for more specific properties which bear directly on their application to the work for which they are to be assigned.

Lest the figures given in Table I be subjected to unwitting abuse, though well-intended, it is well to dwell on the relationship of values for a moment. Petroleum solvents are generally classified in an order of 500 ppm maximum allowable concentration for "safe" working limits. It must be borne in mind that two co-existent hazards are present as well. First, the rate of evaporation which will determine the speed in which a given area becomes saturated to the tolerance level—and second, the flammability limits of the vapors. In many instances the contaminative vapor level may be held below the indicated maximum allowable concentration for health, and yet, the vapor concentration will be found to be within the upper and lower explosion limits for the product and need only an ignition source as a set-up for a catastrophe. This is true of coal tar solvents, alcohols, ketones and esters as well as other types of solvents which are combustible.

Some of the aromatic solvents, particularly those of coal tar origin, are known to be causatives of cancer of various kinds (3)* as well as to produce anemia and other physiological disturbances of more or less severe nature (4). The same comments may be made of the chlorinated solvents group mentioned in the Table (3). Of this group the most dangerous is carbon tetrachloride, which it cumulatively toxic and a poison for which no antagonistic drug is known (5). It degenerates the liver and kidneys, produces lung edema and adversely affects the optic nerves. If the ability of the body to repair itself has been exceeded, in these vital organs, there is no cure. The presence of alcohol at the time of exposure accelerates the degenerative process markedly. The maximum allowable concentration is given as 25 ppm. The olfactory detection limit is 80 parts per million. In other words, if one can smell carbon tetrachloride, there is three times too much vapor in the air for safe working conditions. It is specious reasoning which justifies continued use on the basis that 'only a few gallons a year are used'. Two ounces can kill a man and the courts are more frequently placing the responsibility for carbon tetrachloride deaths and disabilities squarely on the neck of the employer, not only in civil damage and compensation cases, but as to criminal negligence as well.

The last group in the Table, designated as "Safety" solvents (although no solvents are wholly safe) are relative newcomers in industry. They are generally composed of blends of two or more solvents of different base types which are intended to volatilize in general proportion to their ingredient ratios. Mechanically, as liquid cleaning solvents for cold (room temperature) use, they represent a compromise of hazards in an end-product that performs efficiently its intended work. This group is included because of their wide adoption throughout industry, and because the history of their performance, thus far, indicates they have merit. Because these products are sold as proprietories, there is particular need for close cooperation between operating levels and those of safety and hygiene functions. Chemical ingredients and percentages of content should be determined and passed upon by medical personnel before adoption of such products so that adequate control measures may be set up in the light of the hazard levels of the products themselves.

Since it is the purpose of this paper to deal with principles, no attempt will be made to go into the detail of the hundreds of varied cleaning operations which are common to the industry, its supply, distribution and service affiliates. Nor is it practical to include detergents, emulsions and soaps without unduly lengthening this text, although it is to be noted that most of

*Numbers refer to Bibliography at end of article.

TABLE I

Comparative Data of Solvents by Representative Types

Solvent class and kind	Kauri Butanol	Aniline Point, C	Drying Time	Flash Point TCC, F	Maximum Allowable Concentration, ppm
	(1)	(1)	(a)	(1)	(2 & 3)
Aliphatic and naphthenic petroleum solvents:					
V.M. & P naphtha, close	35- 39	125-135	3.5	33- 35	500
V.M. & P naphtha, long	35- 39	125-135	4.5	50- 55	500
Mineral spirits	31- 40	125-150	16.6	95-110	500
Stoddard solvent	34- 40	125-150	20.0	100-110	500
Paint thinner	31- 36	130-150	33.0	60- 90	500
Petroleum spirits	32- 43	130-143	30.0	115-140	500
Gasoline (wnite)	60- 90	80-120	2.8	—10- 40	500
Kerosene (deodorized)	24- 30	125-170	205.0+	125-175	500
Kerosene (fuel grade)	10- 30	130-180	215.0+	80-180	500
Aromatic petroleum solvents:					
Benzol	105-115	25- 32	1.4	0- 15	35
Toluol	95-105	50- 76	3.0	40- 50	200
Xylol	93- 98	51- 58	5.3	80- 90	200
Coal tar solvents:					
Benzene	105	-30	1.4	10- 20	35
Toluene	100	27- 30	3.0	35- 45	200
Xylene	93- 98	-20	5.0	60- 85	200
High flash naphtha	80- 90	20- 30	19.0	95-108	200
Wood turpentine	55	20	22.0	93	100
Chlorinated solvents:					
Methylene chloride	.....	.....	0.4	None	500
Methyl chloroform	.....	.....	0.8	None	500
Carbon tetrachloride	106	.....	1.0	None	25
Trichloroethylene	94	.....	1.5	None	200
Perchloroethylene	89	.....	3.4	None	200
Orthodichlorobenzene	.....	.....	38.0	170	50
Ketones and esters:					
Acetone	.....	.....	0.8	2	1000
Methyl ethyl ketone	.....	.....	1.5	28	200
Methyl isobutyl ketone	.....	.....	3.5	63	100
Ethyl acetate	.....	.....	1.4	29	400
Amyl acetate	.....	.....	8.9	88	200
"Safety" solvents: (b)					
Petroleum-chlorinated blends: (in a class with)					
Slow drying (kerosene)	26- 30	75- 90	105-170	160-190	475*
Medium drying (min. sp.)	40- 55	12- 75	11- 20	125-225	400*
Fast drying (naphthas)	70-100	10- 30	7- 10	125-150	400*
Non-combustible-halides: (to replace carbon tet.)					
Fast drying	100+	Below 2	0.4-1.5	None	275-500*

*Values calculated from ingredients. Subject to hygienist for opinion.
(a) Private correspondence and laboratory tests.
(b) Interpreted from manufacturer's literature.
(1) (2) (3) Numbers refer to Bibliography at end of article.

the technique of selection and the principles involved are applicable as well, to these other classes of cleaners.

The cleaning of electrical apparatus provides a good illustrative medium to demonstrate the process of solvent selection outlined herein. Motors and generators require cleaning. Where practicable, such cleaning is preferably done in central maintenance shops, but often the equipment is too large and must be cleaned at the location where it operates. It becomes immediately clear that the differences in physical conditions of areas where cleaning solvents must be used may forbid the use of one material which is satisfactory in all respects when used in the central maintenance shop, but which, in the blast furnace area, constitutes an explosion hazard.

While techniques of cleaning may vary widely in different shops and plants, the choice of methods is limited to the application of solvent-cleaner by wipe, brush, spray and immersion-soak. In past years, carbon tetrachloride has been widely preferred as a cleaning agent for electrical apparatus. This preference was based on the assumption that four properties of inherent nature were good per se. These properties are: (1) fast drying rate; (2) high dielectric breakdown point; (3) non-combustibility; and, (4) excellent grease-solvency. It is conceded that there are a few areas where this particular combination of properties must be the paramount consideration, but the combination is not applicable to the needs of the average shop.

Examine the effects of high volatility of a solvent on a motor. In substance, the surfaces of the motor are cooled by solvent evaporation, often below the dew-point of the surrounding air and moisture condenses, causing corrosion of shafts and bearing and field-winding leakage. Temperature-change stress, in older motors, results in cracked insulation. Observation of the evaporation of highly volatile solvents from serrated surfaces, such as coil-winding, shows a tendency for the solvent fluid to migrate and boil to the ridge points and to leave, in the valleys, much of the soil it was intended to dissolve. By whatever means applied, losses by vaporization before the solvent contacts the soil, may range from ten to forty per cent of the volume of solvent required to do the work.

When the subject of cleaning solvents is viewed in this light, it would appear that a re-orientation of

viewpoint is desirable. It is pertinent to emphasize the fact that solvents are tools in fluid form. To make a parallel for illustration: wrenches are tools in solid dimensional form. It is neither logical nor good shop practice to attempt to use an allen wrench to do the work of a stillson wrench and it is doubtful if such a substitution would be attempted because the differences are instantly and visually apparent. That there are equivalent differences in the properties of solvents is not so evident by casual and visual observation, hence the need for the application of the engineering approach to the problem of their selection, methods of application and the control of their inherent and potential hazards.

The subject of this paper, "Selection of Solvents and the Control of Hazards," is substantial in its scope as well as its implication. To this author, the primary need lies in gaining better understanding of the principles of solvent selection and control of hazards, in toto: (1) solvents should be selected on the basis of what they must do and the environment of their intended use; (2) the selection process should be the function of a team which is composed of operating supervisors responsible for the work involved, and representatives of engineering, purchasing, fire control, safety and medical-hygiene functions, who are responsible for costs and conservation of equity; (3) simple, but effective, standards for control of quality should be established to assure the continuity of safety and hygiene standards at established levels; and, (4) a continuous and comprehensible program of education, backed by proper standards of hazard-notice labelling, should be instigated so that the misuse and misapplication of solvents can be eliminated to the end that costs may better be controlled and accident losses eradicated.

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DISCUSSION

PRESENTED BY

W. H. BAUMANN, Industrial Hygienist, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

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ANDREW E. CICHELLI, Lubrication Engineer Construction & Engineering Departments, Bethlehem Steel Co., Bethlehem, Pa.

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W. H. Baumann: Mr. Moore is to be commended on his excellent presentation of a subject which is rapidly attaining a level of specialization in industry. I particularly admire the author's comments on the functioning of a team of experts, each of whom contributes his own special talents in selecting a solvent cleaner that will give optimum performance at a fair price level with minimal health and fire risk. Too often the selection of cleaners has been left with the user without considering the other members of the team. However, today, solvent manufacturers are taking the initiative to consult with health and safety people before they attempt to sell their products. In addition, the manufacturers are considerably more cooperative in revealing information about their formulations which they formerly considered trade secrets.

I would like to expand on that portion of the paper concerned with toxicity and volatility of blends. Very few health limits (a limit is defined as maximum allowable concentration) have been adopted for the blends. This is largely because of the absence of animal toxicity studies and the lack of good field data where air analysis is correlated with health experience. To date most of the toxicity studies have been done on pure compounds, i.e., acetone, carbon tetrachloride, etc., which have been used for many years in industrial processes. In the absence of health hazard rating data, i.e., maximum allowable concentration, based on animal and/or human exposure experience, some manufacturers of cleaners publish so-called calculated mac's for their products. Such limits are predicated upon composition of the blend and the mac of individual constituents. The calculator assumes that the vapor composition is similar to that of the liquid and that toxicity effects are additive. The vapor composition may be quite different from liquid composition except, of course, when we have an azeotropic mixture which is rarely found in our modern solvent blends.

The toxicologist does not consider that toxicity effects of mixtures are additive. In fact, the toxicity of a specific substance may be altered out of all proportion when one substance is mixed with others. This has been partially demonstrated in our recent acute pollution episodes in Donora and London. Hence, one should proceed most cautiously in interpreting so-called calculated mac's.

In rating fire hazard of blends one must be cautioned in accepting the manufacturer's value of flash point. Occasionally, a formulation contains a highly volatile, non-flammable chlorinated hydrocarbon and the mixture gives no flash point on initial testing. However, as the volatile constituent is evaporated from the mixture, the residual liquid may give off vapors that are flammable. I believe the manufacturer should supply flash point data over the boiling range of the blend to avoid setting up any false sense of security.

I would like to have Mr. Moore clarify a few points. In one instance, and I quote:

"In many instances the contaminative vapor level may be held below the indicated maximum allowable concentration for health, and yet, the vapor concentration will be found to be within the upper and lower explosion limits for the product and need only an ignition source as set-up for a catastrophe."

The maximum allowable concentration is generally well below the lower explosive limit. A high mac is 500 ppm or 0.05 per cent whereas a low range for lower explosive limit is of the order of 1 to 2 per cent or 10,000

to 20,000 ppm. If the contamination level is below the mac, the vapor concentration should be well below any fire hazard risk.

Another item which I feel sure the author can explain is the toxicity rating of benzene, toluene, xylene from coal tar origin compared with benzol, toluol, and xylol from petroleum origin. Hygienists generally refer to benzene as benzol to avoid confusing benzene, a toxic aromatic, with benzine, a low order toxicity petroleum distillate.

John B. Moore: Mr. Baumann raises three general points in his discussion, and all are well taken.

The first one is his observation as to the caution or admonition on being wary of manufacturers' claims as to the maximum allowable concentration of blended products. There is a great deal of work that remains to be done in measuring, by animal tests and other means, the effects of such combinations. There is, however, a fairly good background among certain of these groups of products in industrial history which indicates that no synergisms of significant nature have, as yet, evidenced themselves.

It simply points up the comment in my paper that it is essential, in the consideration of proprietary blended products, that the producer of them furnish complete formulative information by chemical name and percentage of content, to the industrial health function of the organization considering the product. With this data in hand, it is possible to make a determination as to whether the manufacturer's claims are excessive or reasonable in the light of the kind of usage intended of the product.

Mr. Baumann's question with reference to the disparity in ratings shown in the table is in a distinction made between the comparable by-products or derivative solvents of petroleum base and coal tar base.

While a majority of hygienists rate benzene, toluene and xylol, whether of coal tar or of petroleum origin, in the same order of toxicity, there is little divergence of opinion in standard reference literature. It is one of the points made in the paper, that to try to get a standard text you will find nine different people have nine different things to say, and each one says it from a different viewpoint. It represents a need for standardization of terminology—standardization of bases for expression of values.

I have come to the conclusion, since further discussion with other hygienists, that petroleum products in the benzene, toluene and xylene series should be treated the same as those of coal tar. In other words, instead of the 300 to 500 ppm normally assigned to petroleum base solvents of an aromatic nature, it would be 35 ppm tolerance allowance for benzene and 200 ppm for toluene and xylene respectively, regardless of the origin.

On Mr. Baumann's reference to the explosion limits versus toxic limits, perhaps my own opinion entered into the setup of the table. Using an arbitrary maximum determination of 500 ppm as the safe working limit, confused the issue. A number of solvents have been rated both by the ASTM and the American Conference of Government Industrial Hygienists as high as 1,000 ppm. My own opinion is that maximum allowable concentrations over 500 ppm are talking pure theory. That has been reflected in my placing an arbitrary limitation of 500 ppm for purposes of this paper.

However, at 1,000 ppm for some of the solvents used as reference by the authorities mentioned, significant explosion hazard risk can be assumed to occur in areas where such solvents of a flammable nature are used. Some work on this score was done by Professor Robin Beech, who is an authority on static electricity and static electricity explosion causes, and reported to the American Society of Safety Engineers, North Jersey Section, last winter.

His point, which was established by tests, showed that vapor drifts throughout a closed area cannot be measured as a standard of concentration at any single point. In other words, it cannot be considered as uniform in a room. Vapors will tend to concentrate and diffuse as the vapor drift occurs throughout an area, for which reason you will get high concentrations that need only a source of ignition, at the point where that concentration occurs, to get an explosion.

Andrew E. Cichelli: We should compliment the author on a very fine and complete paper on this subject, a subject in which I am afraid most lubrication men become involved by default.

The author takes us to task and, properly so perhaps, for not giving solvents their just attention. Nevertheless, we at Bethlehem, safety-minded that we are, do have a program and a procedure for the selection of solvents, at least from a safety standpoint.

Each plant planning to purchase a product, will ask a sample be sent to our chief industrial hygienist's laboratory where it is examined to determine what safety precautions must be taken. Upon analysis, a report is written that reverts to the plant, in which they are told what must be done to use the product safely. If you will recall the author's paper, oftentimes considerable expense is involved in insuring the safe use of some products. In our case, though a product is not actually condemned, in effect the high cost required for safe operation would discourage its use.

So far we have had a minimum of difficulty from a safety aspect by following this procedure.

E. T. W. Bailey: I think Mr. Moore has done us a service in emphasizing attention to carbon tetrachloride. An electrician recently came close to losing his life at our plant from using this material in a confined space.

Mr. Moore, in areas that are confined, would the use of carbon tetrachloride be condoned if the man was equipped with a mask and a flow of air used to keep down the risk of passing through the dew point—in the case of electrical equipment?

John B. Moore: The use of carbon tetrachloride as a cleaning agent in industry is absolutely unnecessary, and it is absolutely uncalled for for any operation that I have seen in fifteen years.

The dangers of carbon tetrachloride are so great that I would class the product with radium and arsenic. To put either in the hands of a person untrained in medical and hygiene work is, in my opinion, rather foolhardy, in view of the fact that there are replacement products available which do equivalent types of work and which can be procured easily from a number and variety of sources of supply.

I would say that the use of carbon tetrachloride is simply unnecessary in the field of cleaning.

PREVENTIVE CRANE

By
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Paper presented at Chicago regional technical meeting of the American Iron & Steel Institute, November 2, 1955.

▲ THE term "preventive maintenance," as applied to steel plant machinery and equipment, is widely used and possibly not so widely understood.

Webster defines the word "preventive" in part as "devoted to or concerned with prevention; as of an evil." The word "maintenance" is defined in part as "the upkeep of property and equipment."

Preventive maintenance may consequently be defined as "the upkeep of property and equipment in a manner devoted to, or concerned with, the prevention of evil; the evil in this case being the breakdown or premature aging and deterioration of said property and equipment."

The relative importance of a paper on preventive *crane* maintenance is obviously a function of the relative importance of *cranes* in the iron and steel industry.

Information tabulated by the AISI indicates an annual national ingot capacity of something over 125,000,000 tons, and a hot rolled steel product capacity of over 97,000,000 tons. It has been authoritatively estimated that each ton of steel may be handled as many as 30 to 40 times during its production, usually in small lifts of 10 to 20 tons. This would indicate almost 300,000,000 lifts per year, or ten lifts every second of every day of the year.

This prodigious amount of lifting is done by an estimated 10,500 cranes of many types, sizes and descriptions, each of which is essential to the operation of which it is a part.

In order to keep these thousands of vital cranes operating safely, dependably, economically and continually, the application of preventive crane maintenance is an absolute necessity.

This application is, however, not a simple concept. Frequently the mention of preventive maintenance brings to mind the vision of a repairman with his wrench going about checking bolts, or an oiler with his oil can squirting lubricant here and there.

Actually, such activities represent only one small fragment of the complete picture. A bit of reflection on the basic idea of preventive maintenance will indicate that the first phase must naturally be concerned with the engineering of the crane, with proper regard for anticipated operating conditions, type of service, clearances, hook approaches, types of buildings and runways, matching of associated cranes, speeds, and special features, including safety devices.

Following proper engineering, and assuming satisfactory fabrication and manufacture, it is essential that the crane be correctly erected and tested.

A properly constituted organization, based on sound economic principles, must then be provided to service and maintain the crane.

This organization must, of course, operate with the best methods with respect to inspection, delay investigation, scheduling and planning, training of personnel, modernization, lubrication, shop facilities, spares and spare records, and safety.

Lastly, the above functions must be properly associated with, and supplemented by, proper crane operator training programs, close cooperation between the operating and maintenance departments, adequate maintenance of buildings and runways, and good housekeeping throughout the plant.

ENGINEERING

The first, or engineering, phase of preventive maintenance starts, with the establishment of the need for

a crane and the justification for the expenditure necessary to procure it. At this point the capacity and speeds must be checked against operating requirements. The crane must not only match the output of the operating units, but must also match other cranes in related units to eliminate the possibility of a 25-ton crane feeding 25-ton lifts to a 10-ton crane, or vice-versa, with consequent possible hazard to both equipment and personnel.

Service and conditions must also be checked, to establish whether a standard-duty or heavy-duty design is required. Obviously, an open hearth charging crane or mold yard crane will make infinitely more moves over a period of time than a power house crane, and will be exposed to extreme heat and dirt as well. Structural, mechanical and electrical design will be greatly influenced by such factors, as well as by the importance of dependability, reliability and ease of operation.

MAINTENANCE

Safety of the operator, maintenance men, and ground personnel must be considered. Operator safety will be influenced by the provisions for access to the crane; location, size and type of oiling or maintenance platforms; location, size and type of handrailings; location and number of main power switches; trolley and bridge clearances; provisions for cleanliness, such as open gratings on footwalks to prevent dirt build-up, or elimination of wells on bridges and trolleys to prevent oil and dirt accumulation; reasonable enclosure of electrical components such as switches, control panels, controllers, and heaters; location of walkways and similar thoroughfares reasonably remote from "hot" electrical conductors and collectors; adequate guarding or enclosure of gears, couplings, etc.; provisions for signaling to adjacent cranes if crane is "down"; power braking if crane is heavy; and possibly air cleaning and/or air conditioning for the cab if conditions require it.

Safety of the maintenance man will include essentially the same items as pertain to the operator with particular emphasis on clearances, repair platforms, and cleanliness. Repair hoists or provisions for same are sometimes essential to safety, as are automatic or semi-automatic lubrication systems.

The safety of ground personnel is of course highly dependent upon the condition of the operator and the efficiency of the maintenance men, which conditions, of course, are greatly influenced by the engineering of the safety items already given. Furthermore, the safety of ground personnel will be dependent to a great extent upon additional engineered items such as operator visibility, ease of control, hook approaches and clearances, adequate signal bells or horns, location of crane with respect to building arrangement, adequacy of hoist limit switches, and guarding of sheaves.

Another important phase of the engineering of a crane from a preventive maintenance standpoint is the duplication of existing equipment, if possible. In many cases an actual improvement in design will be nullified by the increased cost of providing the necessary spares. In such instances a careful study is sometimes required to determine the break-even point of improvement versus duplication. Maximum accessibility of all parts requiring service or maintenance is also essential.

ERECTION AND TESTING

Following the proper engineering of a crane, and assuming that the crane has been procured in such a manner that it meets the specifications and has been properly manufactured, the erection phase has much to do with the amount of maintenance which will subsequently be required.

During erection, parts must be handled safely in a manner which will not spring them out of line or otherwise damage them. Dirt, moisture and other foreign material must be kept out of bearings and gears. All mechanical and structural parts must be properly alined before final fastening, and most importantly, the final fastening must be done securely and as per specification, using the proper sizes and types of rivets, bolts, or welds.

Electrical components must be installed without damage, wires pulled-in without fraying, and junction box lids and similar openings closed and sealed tightly. Lubrication systems must be tested thoroughly and all lubricated points checked for proper amount and type of lubricant.

Lastly, all controls must be operated and adjusted for proper function, and safety devices such as brakes and limit switches checked and tested.

In the case of hot metal cranes, a test load somewhat exceeding the nameplate capacity may sometimes be lifted as a final check, after which a thorough inspection is made to detect any over-stressed or defective components.

A crane so erected and tested will minimize the amount of subsequent "corrective" maintenance and will permit fullest use of the organization for "preventive maintenance."

ORGANIZATION

The organizations which maintain cranes vary considerably from company to company, from plant to plant, and even from department to department. In all cases, however, it can safely be stated that the size and type of organization will be based upon the necessities.

We usually find crane maintenance handled by relatively small groups of men under a central parent organization. This parent organization may be mechanical, electrical, or a combination of the two departments. It will normally have a superintendent, an

assistant, a number of general divisional foremen, and possibly a central crane inspector.

Some of these divisional foremen will frequently head-up central units such as the mechanical repair shop, the electrical repair shop, and possibly a special crane repair unit, the functions of which will subsequently be discussed along with the other preventive maintenance methods and procedures.

The balance of the divisional foremen will be charged with the maintenance of cranes in rather large geographical areas, encompassing a number of operating departments.

In each of these operating departments we usually find a unit maintenance foreman who reports to one of the divisional foremen.

These departmental or unit foremen supervise small, compact, and efficient groups of maintenance men who do the actual work on the cranes. This group may, in larger units, include turn foremen or repair foremen who report to the unit foreman.

The actual make-up of the individual units will usually be tailored to suit the operation. For instance, in an open hearth we will frequently find a top echelon of motor inspectors or millwrights, supported by repairmen, helpers, oilers, and crane cleaners. Some of the top-rated men may be assigned to specific limited duties, such as crane inspection, lubrication inspection, etc. In a smaller department we normally would find some positions, such as oiler and crane cleaner, either curtailed or eliminated, and fewer top-rated men assigned to specific limited duties.

All of these unit organizations, of course, have access to the facilities of the parent organization, such as electrical shop, mechanical shop, and central crane repair unit, as well as to general plant facilities and services, including transportation, purchasing, etc.

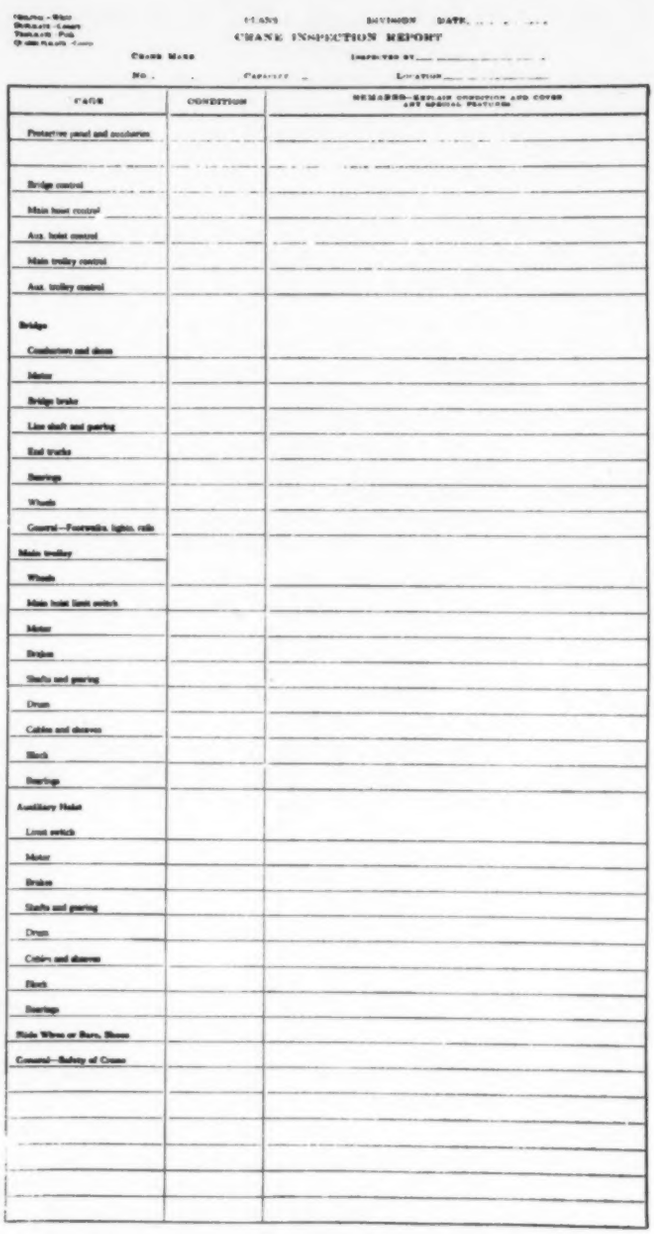
METHODS

The methods used by maintenance organizations vary probably as much as the organizations themselves, especially in details; but the general fundamentals are practically universal in their acceptance and use.

Generally speaking, a problem cannot be solved unless we know the problem. In crane maintenance we are concerned with eliminating troubles before they start, or at least, in their incipient stages of development. We must therefore locate these troubles. Indications of most troubles in these early stages are usually obtained only through routine and regular inspections, although sometimes apparent to an alert operator prior to discovery by inspection. Inspection in many large plants can be broken down into several categories as follows:

1. Inspection by the crane operator.
2. Inspection by the regular maintenance man (frequently incidental to some other repair mission).
3. Inspection by the unit crane inspector.
4. Inspection by the central crane inspector.
5. Miscellaneous inspection, such as by operating foremen, unit maintenance foremen, crane oilers, crane cleaners, etc.

Inspection by the operators consists primarily of



CRANE INSPECTION REPORT

CAGE	CONDITION	REMARKS—EXPLAIN CONDITION AND COVER ANY SPECIAL FEATURES
Protective panel and enclosures		
Bridge control		
Main hoist control		
Aux. hoist control		
Main trolley control		
Aux. trolley control		
Bridge		
Conductors and shoes		
Motor		
Bridge brake		
Line shaft and gearing		
End trucks		
Bearings		
Wheels		
Control—Footwalks, lights, rails		
Main trolley		
Wheels		
Main hoist limit switch		
Motor		
Brakes		
Shafts and gearing		
Drum		
Cables and sheaves		
Block		
Bearings		
Auxiliary Hoist		
Limit switch		
Motor		
Brakes		
Shafts and gearing		
Drum		
Cables and sheaves		
Block		
Bearings		
Ride Wires or Bars, Shoes		
General—Safety of Crane		

Figure 1 — Form used for recording crane inspection.

a quick but thorough check of hoist limit switches and control operation, and a visual check of the overall physical condition of the crane, usually at the start of each turn. It may also include spot checks of any unusual conditions developed during the turn. These reports are usually verbal, or on a very simple check-off type of form, and are normally submitted to the operating foreman who passes them on to the maintenance people, if warranted.

Inspection by the regular maintenance man may be scheduled and thorough in smaller units, or may be impromptu and incidental to another repair job in larger units. Such inspections, if thorough, might be recorded on forms similar to Figures 1, 2, and 3, or if limited or impromptu, on a form similar to Figure 4. These are filed and become a permanent record, with the possible exception of Figure 4, from which the parts pertaining to a special crane might be recorded on the individual card record for that crane.

Inspection by the unit crane inspector is a periodic,

Charger No._____ Date_____ Inspector_____

Part	Condition	Remarks
CONTROL PANELS		
E. Bridge Control		
W. Bridge Control		
Trolley Control		
Peel Revolve Control		
Hydraulic Pump Starter		
Blinker Light Control		
Miscellaneous		
BRIDGE		
E. Motor		
W. Motor		
Brakes		
Lineshafts and Gearing		
End Trucks & Wheels		
Bearings		
Girders, Footwalks & Bumpers		
Cab - Glass, Heater, etc.		
Lights & Siren		
Safety Stops		
Lubrication System		
Miscellaneous		
TROLLEY		
Trolley Motor		
Brake		
Reel & Yoke		
Shafts & Gearing		
Bearings		
Wheels & Rails & Spring Suspension		
Lubrication System		
Miscellaneous		
PEEL REVOLVE		
Motor		
Brake		
Shafts & Gearing		
Bearings		
Miscellaneous		
HOIST & PEEL HYDRAULIC		
Pump Motor		
Shafts		
Bearings		
Hydraulic: Pumps, Piping, Cylinders and Hoses		
Liquid Level and Breather Filter		
Miscellaneous		
CABLE REELS		
Peel Revolve Reel & Cable		
Trolley Motor Reel & Cable		
Hyd. Pump Motor Reel & Cable		
Solenoid Control Reel & Cable		
Miscellaneous		
MAIN POWER POLE & SHOES		
MAIN SWITCH & MAIN CONTROL SWITCH		
MASTER SWITCHES & AUXILIARY SWITCHES IN CAB		
GENERAL WIRING		
RESISTANCE		
MISCELLANEOUS		

Figure 2 — Another form used in crane inspection.

WEEKLY LADLE CRANE INSPECTION REPORT

Location..... Crane No..... Date.....

Main Hoist

Cables.....

Spreaders and Sheaves.....

Top Sheaves and Equalizers.....

Drum and Drum Gears.....

Drum Drive Shaft, Bearings and Gears.....

First Shaft from Motor Bearings and Gears.....

Motor.....

Main Hoist Brakes.....

Main Hoist Control.....

Contact Bars and Shoes.....

Limit Switch.....

Lubrication.....

Remarks.....

.....

.....

.....

.....

Inspected by .....

Figure 3 — This form is used for weekly ladle crane inspection report.

regularly scheduled function and is recorded on forms similar to Figures 1, 2, or 3 which, when filed, become a permanent record. Such inspections are usually weekly for hot metal cranes, and monthly for all others. The thoroughness of the inspections and the items covered are evident upon close scrutiny of these forms.

Inspections by the central crane inspector are usually made once or twice per year, and the reports are submitted in letter form to the crane maintenance and operating department superintendents. These reports constitute a check upon the unit inspectors and are filed and vigorously followed up by these superintendents.

Miscellaneous inspections are usually made in connection with a specific complaint, or as a by-product of some other activity, and if recorded at all, are usually entered on the individual crane record cards.

Card records for each crane are usually kept in each unit, and all inspection information not filed on forms similar to Figures 1, 2 or 3 is entered directly on these cards.

Another method of determining the location and magnitude of specific crane maintenance problems is in the use of delay reports. These reports may originate either in the operating or maintenance departments. Such reports, submitted by maintenance people on forms similar to Figures 4 or 5, are filed and become a permanent record.

Operating departments frequently tabulate and total their delay reports for all of the cranes in the department for monthly or weekly periods, with the percentages of total delays contributed by each crane. These reports are very helpful in pinpointing the worst delay sources so that additional preventive measures may be applied. A typical delay tabulation is shown on Figure 6.

Some scheduling and planning are of course necessary even for inspection of cranes, but the bulk of it comes into being in connection with the actual maintenance of the cranes. In many plants the oiling and greasing schedules are the basis for much of the maintenance scheduling. Figure 7 shows a typical crane oiling and greasing schedule. Close adherence to such a schedule not only provides time for adequate lubrication and inspection, but also permits scheduling of minor maintenance jobs such as brake adjustments, shoe changes, control repairs and adjustments, and similar small jobs at the same time.

Generally speaking, scheduling covers repetitive items such as cable changes, trackwheel changes, bearing or coupling repacking, motor brush changes, contactor tip changes, and the like. Card records are maintained, sometimes with a tickler file, based either upon

past experience or manufacturers' recommendations, and as the items come up on the schedule, they are assigned to the maintenance men for completion. For proper scheduling, it is also essential that complete drawings and technical bulletins be kept on file so that the scope of the scheduled work is readily apparent.

Planning, as contrasted to scheduling, covers the working out of the step-by-step procedures to be followed in the actual doing of the work. Here, too, it is essential that complete drawing files be maintained in the units so that the scope of projected jobs may be checked and methods of doing set up.

In many cases, a step-by-step plan will be worked out, with estimated times assigned to each step, in order that no items of equipment, manpower, or material will be missed. Such plans always incorporate the safety of personnel as a major item.

DAILY REPORT—ELECTRICAL MOTOR INSPECTOR

Figure 4 — The daily report of the electrical motor inspector is also helpful in picking up repair jobs.

Figure 5 — The daily report shown is used by operating or maintenance crews.

TURN FOREMAN REPORT

DATE ..... DEPARTMENT ..... TURN .....

1. Electrical delays

Amount				
Unit				
Cause				

Recommendations .....

2. Damage to equipment: .....

3. Fires—Unit and causes: .....

4. Safety items: .....

5. Employee contacts: .....

6. Miscellaneous: .....

TURN FOREMAN

OPEN HEARTH CRANE DELAYS

Month of May - 1955

	Total Delay Time	Hours Scheduled	Percent Delay Time	Total Delay Time	Hours Scheduled	Percent Delay Time
STOCKYARD						
#517	12:40	744	1.70			
518	23:00	744	3.09			
519	6:10	744	.82			
520	25:45	744	3.46			
521	19:30	744	2.62			
522	42:40	744	5.73	129:45	4464	2.91
FLOOR CHARGER						
#550	34:00	744	4.57			
551	23:20	744	3.13			
552	30:05	744	4.13			
553	16:00	744	2.15			
554	42:15	744	5.67			
555	23:50	744	3.20	169:30	4464	3.80
FLOOR 75 TON						
#510	27:55	744	3.75			
511	21:15	744	2.85			
512	13:50	744	1.86			
532	6:25	744	.87			
533	11:45	744	1.57	81:10	3720	2.18
PIT						
#504	36:15	744	4.87			
506	38:50	744	5.22			
556	34:35	744	4.64			
557	16:40	744	2.23			
558	32:00	744	4.30			
559	11:20	744	1.52	169:40	4464	3.80
MOULDYARD						
#495	33:00	744	4.43			
497	27:25	744	3.68			
499	8:10	744	1.10			
502	39:07	744	5.25	107:42	2976	3.62
STRIPPER						
#482	24:20	496	4.89			
483	7:50	496	1.60			
496	1:50	496	.38	34:00	1488	2.29
GANTRY						
#468	18:45	372	5.04			
469	81:45	372	21.97	100:30	744	13.50
AVERAGE:				792:17	22,320	3.55

Figure 6 — A tabulation of delays points to trouble sources.

The best program of inspection, delay investigation, and scheduling and planning is worthless, however, unless we have the trained manpower to implement the program. Both supervisory and hourly-rated personnel must be trained not only in the technical aspects of the job, but also in the basic philosophy of preventive maintenance. Many of us have heard old-timers boast with pride of the speed with which they could change hoist-motor armatures, or trackwheels, with no thought as to what was causing the repeated failures of same. They must be taught that it is much better to not spill the milk in the first place than to be the most adept at cleaning up the milk after it is spilled.

Supervisors are trained on the job in various ways. Frequently such instruction is nothing more than a demonstration by fellow supervisor, or by a superior, who has been previously schooled on the topic. It may also be in the form of literature or bulletins issued from time to time.

On some occasions special classes are held for off-the-job training of supervisors, with instruction either by other supervisors or by outside experts. Sometimes it is well to send a supervisor to a manufacturer's plant for specific instruction on that manufacturer's product. This supervisor can then train others, either on or off the job.

Hourly-rated personnel can be trained on-the-job,

COPY

April 6, 1955

Superintendent, Open Hearth

All Concerned

Crane Oiling and Greasing Schedule

The attached weekly schedule for oiling and greasing 75 Ton Floor Cranes, Charger Cranes and 175 Ton Pit Cranes is effective immediately.

Every effort should be made to see that the Electricians are given the scheduled cranes at a suitable time on the 7-3 turn. The particular time is to be determined by the Melter or Pit Foreman according to the operating schedule for the turn.

This schedule is designed to see that each crane receives adequate maintenance and inspection at least once a week. Additional maintenance will be at the discretion of the Melter, Pit Foreman or Electrical Foreman, preferably at times the cranes are not in use.

CRANE OILING AND GREASING SCHEDULE

Monday (7-3 Turn)	Thursday (7-3 Turn)
512 - 75 Ton Crane	532 - 75 Ton Crane
550 - Charger Crane	554 - Charger Crane
556 - 175 Ton Crane	506 - 150 Ton Crane
Tuesday (7-3 Turn)	Friday (7-3 Turn)
510 - 75 Ton Crane	533 - 75 Ton Crane
555 - Charger Crane	552 - Charger Crane
504 - 150 Ton Crane	557 - 175 Ton Crane
Wednesday (7-3 Turn)	Saturday (7-3 Turn)
511 - 50 Ton Crane	553 - Charger Crane
551 - Charger Crane	558 - 175 Ton Crane
559 - 175 Ton Crane	

_____

Superintendent
Open Hearth Department

Figure 7 — Oiling and greasing schedules may set a basis for some maintenance scheduling.

very much as we train supervisors, or they may be given special instruction. Some large plants have Helper's Schools at which the electrical and mechanical fundamentals of crane maintenance are taught. These schools have been very successful.

In any such program, it is essential that all personnel be kept up-to-date and abreast of new developments. This can readily be accomplished through current literature, bulletins, and refresher courses of instruction by qualified supervisors.

In addition to keeping personnel up-to-date and abreast of the times, it is vitally necessary that the cranes themselves be kept up-to-date and modern to the greatest extent possible. Many of the estimated 10,500 cranes active in the steel industry are 30 to 40 or more years old. Preventive maintenance on these older cranes is much like maintenance on a 1910 automobile—it might be kept in good shape, but it is still a 1910 automobile, and as such will not be as free from breakdowns, or from excessive upkeep cost, as a new model.

Many of these older cranes can be modernized for a fraction of the cost of a new crane, and will perform and respond to preventive maintenance much like a new crane.

This modernization may be a day-to-day process, on a more or less hit-or-miss basis, or it may be on a definite program. One large steel plant has been very successful with a long range crane rehabilitation program. This plant has over 240 cranes, many of which are in the 30 to 50 year old category.

The long-range program was instituted in 1950, with a schedule projected five years ahead. All cranes requiring major repairs or modernization were included for attention during the five-year period, with the most urgent scheduled for earliest attention. This provided a bogey of a definite number of crane jobs per year, for which financial, engineering, and construction plans could definitely be formulated on an annual basis.

At the end of each year the plan is reviewed and rescheduled, and an additional year added on, so that the plan always covers a five-year period.

The plan has been handled through the general crane repair unit, with cooperation of engineering and operating departments, and has been very successful.

The actual modernization, whether done piece-meal or as part of a program, includes necessary changes to electrical, mechanical and structural components to approximate the condition of a new, modern unit.

The electrical changes ordinarily include replacement of manual controllers with magnetic controllers, replacement of cast iron resistors with welded steel resistors, complete replacement of conduit and wiring, replacement of switches with new switches or protective panels, replacement of electric brakes with new or rebuilt brakes, repair or renewal of collector rails and shoes, replacement of paddle-type limit switches with modern enclosed limit switches, and repair or renewal of all auxiliary devices such as magnet reels, magnet controllers, lights, heaters, signals, sanders, etc. Motors are also replaced with rebuilt motors including such improvements as oversized armature coils with high-temperature insulation, roller bearings in place of sleeve bearings, and high-temperature field coils.

Mechanical changes frequently include replacement of ordinary wheels, sheaves and gears with hardened types, replacement of sleeve bearings with anti-friction bearings, increase in size or change in grade of shafting or similar parts proven to be troublesome, replacement of cast-iron drums with steel drums, replacement of mechanical hoist-brakes with electric brakes, replacement of mechanical bridge brakes with hydraulic brakes, replacement of obsolete couplings with modern units, and installation of automatic or semi-automatic lubrication systems on trolleys and bridges.

Structural changes may include replacement of fabricated end-trucks with steel castings, addition of auxiliary girders and bridge-drive supports, new and larger walkways and handrailings, new operator's cab and stairways, new or rebuilt main girders where warranted, new coupling and gear guards, new oiling or access platforms, new trolley rails, new end ties, wear plates on girders if required, new or reinforced supports for collector rails, covers or shelters over critical parts of outside cranes, and replacement of all loose rivets.

The number of the above items included on any particular crane is of course a function of the condition of the crane, its age, its importance, and severity of service.

Lubrication has previously been mentioned with reference to engineering, erection and testing, organization, inspection, scheduling, and modernization. Taking a closer look at crane lubrication, we find that it falls into two general categories—oiling and greasing.

Oiling on older cranes usually applied to trackwheel oil cellars, motor ring-oiled bearings, open or partially-enclosed gearing, and occasionally to enclosed gear boxes. On newer cranes oiling is now usually limited to enclosed gears and gear boxes which require very little attention except for frequent checking of oil level and periodic changing of oil. Many of these modern gear boxes include circulating oil pumps and filters.

Greasing on older cranes usually applied to bronze or babbitt sleeve bearings which required daily or sometimes almost hourly injections of grease from a hand gun. On more modern cranes, greasing applies to practically all of the anti-friction bearings on the motors, trackwheels, sheaves, drive-shafts and some gear boxes. There are few, if any, sleeve bearings or plain journals on a modern crane. Most of these cranes utilize semi-automatic, pump-type systems for grease lubrication.

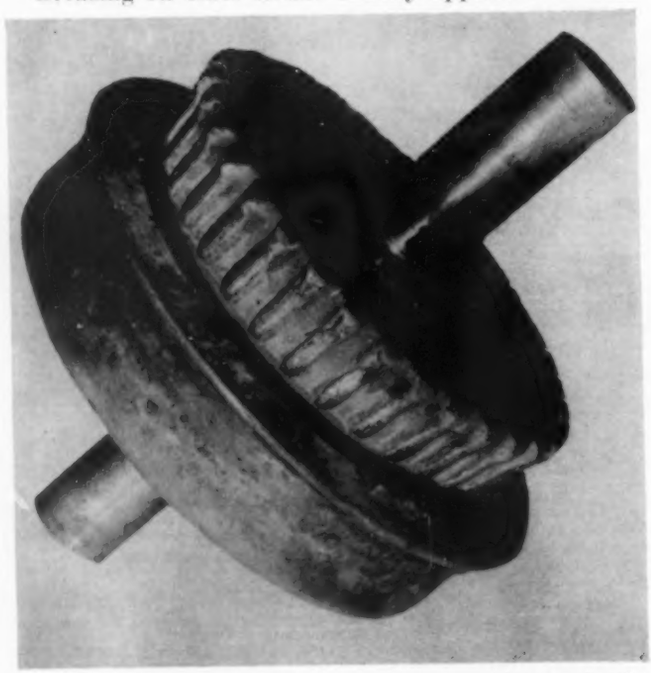


Figure 8 — Lack of lubrication and dirt are factors in the short life of this gear.

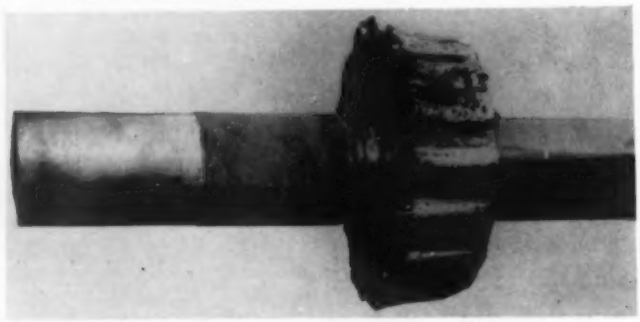


Figure 9 — This is the pinion for the gear of Figure 8 which was also quickly worn out.

Figure 10 — Lack of lubrication and proper inspection resulted in equalizer sheave and pin failures shown here.

Figures 8 and 9 show a gear and pinion which wore out in a very short time on an obsolete and now scrapped open hearth charging machine due to lack of lubrication and excessive dirt pick-up on the teeth.

Figure 10 shows an equalizer sheave and pin which wore out due to lack of lubrication and proper inspection.

In this plant such failures have been largely eliminated through modernization, better inspection, and better lubrication.

Of particular importance on the centralized lubrication system is the matter of inspection of the system itself. Frequently, it is found that branch lines become broken or detached, or distribution boxes plugged which, unless discovered, will starve bearings of lubricant causing subsequent failure.

Summarizing, proper modern lubrication entails careful engineering and application of lubrication systems, a specific organization to do the lubricating and to inspect for proper lubrication, and a good schedule and card-record system to insure that each item is lubricated when necessary.

Another important component of preventive crane maintenance is the electric repair shop, which, as mentioned in connection with organization, usually comes under the central or parent department. This shop repairs all motors, controls, brakes, heaters, resistors, magnets, and miscellaneous items of electrical equipment removed from cranes in the field and sent to the shop for service. While this unit is essentially a repair organization, it renders an additional valuable service through its records.

In other words, if shop records indicate that a certain crane motor is failing repeatedly for the same reason, the shop will work with the district foreman to determine the cause. If the cause is in the motor control, or lubrication, or similar outside influence, the shop may recommend changes to correct, or may let it up to the district people. If the cause proves to be a motor deficiency, however, such as inadequate bearings, lack of thermal capacity, improper commutating ability, or the like, the shop will make the necessary corrections to eliminate the condition, if possible. The shop therefore serves a vital role both in detecting and correcting crane electrical troubles and is definitely a big factor in preventive maintenance.

The procurement and handling of spare parts is another item worthy of careful consideration. It is generally recognized that parts will wear out or fail and must be replaced. To prevent excessive downtime while waiting for new parts, spare parts must be on hand. In many plants these spares are handled on a very loose, uncoordinated basis. This results in needless duplication of spares, excessive inventories, and still worse, lack of vital spares when needed.

It has been found that the handling of all spare parts

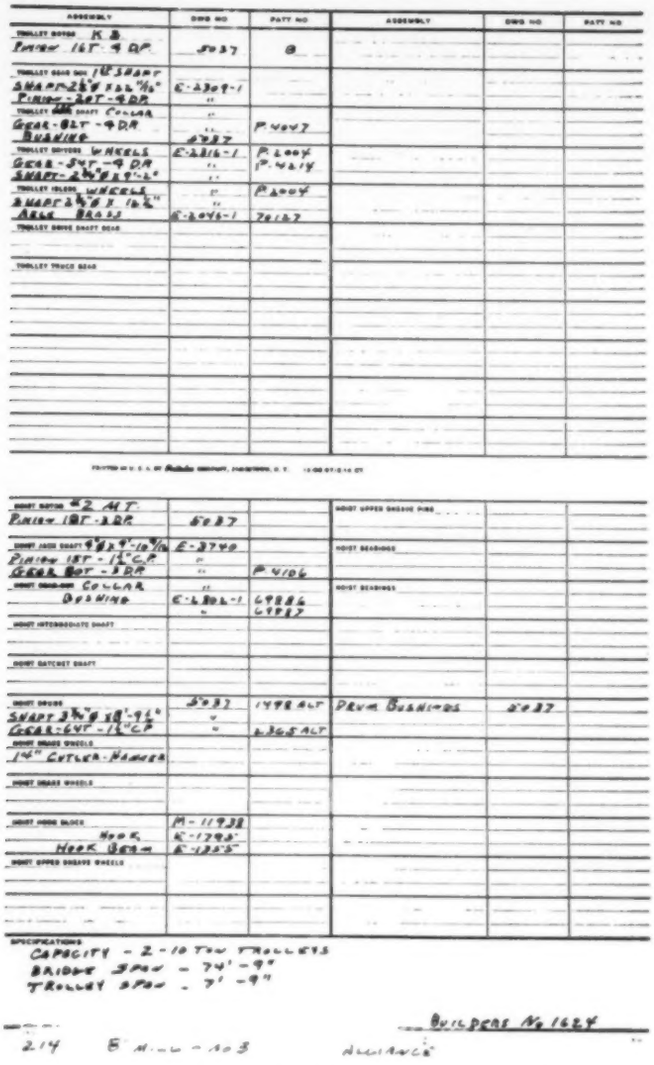


Figure 11 — Front of two-sided card which lists all crane parts.

Figure 12 — Back of two-sided card which lists all crane parts.

through one central agency, with adequate files, drawings and records, is very satisfactory.

Under this scheme, all works orders originating in the various maintenance districts clear through the central crane repair unit. This unit has a complete visible-index card file on all crane parts, and, of course, complete drawing files on the same. The order is first checked for accuracy against a two-sided card listing all parts pertaining to that crane, as shown on Figures 11 and 12. The individual part involved is then checked and recorded on another two-sided card shown on Figures 13 and 14, which also shows all places where this part is used in the plant, and the status of the plant-wide inventory of this part. The order is then approved and forwarded to the proper shop or to the purchasing people. The central crane repair unit foreman will work with the originating districts in either expediting delivery in case of dangerous lack of spare protection, or in the reduction of inventories in event of duplication or excess.

The central crane repair unit also maintains visible-index card records of hook inspections and cable changes as an adjunct to the district records. These district records to some extent duplicate portions of the central records, but usually include more information as to causes of failure of the parts, operating life, etc.

The central crane unit also maintains a smaller file of large spare units such as stripper crane rams, large hoist drums, and the like, which may be available on a company rather than plant basis, with consequent elimination of duplication and reduction of inventories of these costly parts.

The physical care of spare parts is very important. Where possible, they are racked in steel racks and handled with hoists located for maximum convenience and safety to personnel. Motors are also racked several tiers high in special racks. In all cases, finished surfaces are protected with grease, lagging, special coatings, or the equivalent.

Lastly under methods, but of great importance, is the matter of safety. The crane maintenance man must constantly be trained and educated on safety. On a plant-wide basis this takes the form of large signs, safety bulletins, first aid training and representation at general body safety meetings. Departmentally, this is done through safety meetings, literature and bulletins, and job-safety analysis. In the individual units, we have group safety meetings, job planning meetings, individual instruction, and again, job-safety analysis.

COMPONENT PARTS				
	DESCRIPTION			DATA
1	SHAFT		C.R.S.	2½" ϕ x 22 11/16"
1	MOTOR PINION	B.	F.S.	16T - 4DP (Dwg 5037)
1	GEAR	P-4052	R.S.	82T - 4DP
1	PINION		F.S.	20T - 4DP
	BURNINGS	1241	P.B.	(Dwg 5037)

ASSEMBLY TROLLEY FIRST SHAFT
E-2309-1 | 59-61-214-220-421-422-423

Figure 13 — Front of two-sided card for listing individual parts.

E-2309-1

ORDERED				RECD		USED				
DATE	DIST. NO.	MACH. NO.	ANT.	DATE	ANT.	DATE	CRANE NO.	POSITION	QNT. REPLACED	ON HAND
5/6/54	BE 3A40	13905	1	5/10/54	1	5/14/54	220	—	WORM GEAR	
5/6/54	BE 3A46	17983	1			5/14/54	220	—	BROKEN PINION	
5/6/54	DY 7278	23492	1							

ORDERED				RECD		USED				
DATE	DIST. NO.	MACH. NO.	ANT.	DATE	ANT.	DATE	CRANE NO.	POSITION	QNT. REPLACED	ON HAND

Figure 14 — Back of two-sided card for listing individual parts.

This job-safety analysis is a concept which has existed in some form for many years but has really taken hold relatively recently. There are numerous ways to develop this program, but usually it is coordinated through the central or parent crane maintenance department, where a file is maintained of all job-safety analyses, with a cross-referenced card file index. A bogey of jobs to be studied each month in each unit is set up and as the analyses come in they are checked and indexed.

The analysis itself consists of a step-by-step breakdown of each crane maintenance job into its basic elements, with a detailed listing of each tool, move, hazard, and precaution. The study will frequently unearth some hazard or extra move not before apparent, with the result that most jobs so studied are usually improved both as to efficiency and safety. The cross-indexing permits all units to benefit from the experience on each unit, and is very helpful.

Printed rules and regulations for maintenance safety are also widely used. We have company-wide distribution of rulebooks for crane maintenance men. Within each plant we have additional rules necessitated by conditions unique to that plant, and within individual crane maintenance units we have additional rules tailored to the situation in that department. While it would admittedly be foolish to enumerate large numbers of such rules herein, we can call attention to several basic items. One of these is the rule that any crane being worked upon must be identified by a blue flag, or equivalent warning light. Another is the rule that before work is started, the main power switch must be blue-flagged out or locked out. If a crane is to be jacked up, or any part worked upon which neces-

Figure 15 — This opening presented a hazardous condition on a crane at a sintering plant.

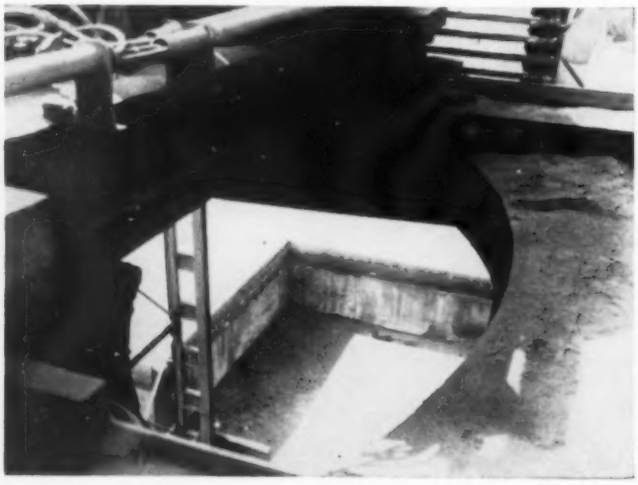


Figure 16 — Addition of a walkway removed the hazard illustrated in Figure 15.

CRANE OPERATOR EXAMINATION

NAME _____ CHECK SYM. & NO. _____ DEPARTMENT _____

QUESTIONS TO BE ASKED OPERATOR BEFORE GOING UP ON DESIGNATED TEST CRANE		
QUESTIONS	YES OR NO	COMMENTS IF ANY
1. Has he read the Cranemen's Code Book "Rules for Crane Operators, Crane Directors, Hook-Up Men and Repairmen"?	YES ☐ NO ☐	
2. Does he know how to demonstrate the proper hand signals and give their meaning?	YES ☐ NO ☐	
3. Has he had 72 hours on a crane?	YES ☐ NO ☐	
4. Does he know what temporary stops and red lights are used for on a crane runway?	YES ☐ NO ☐	
5. Does he know the purpose of a blue flag in a switch and the proper way to flag out a switch?	YES ☐ NO ☐	
6. Does he know the proper procedure for testing limit switches?	YES ☐ NO ☐	

ITEMS TO BE CHECKED WHILE ON DESIGNATED TEST CRANE		
1. Does he pull and flag switch before going on top to check and oil?	YES ☐ NO ☐	
2. Does he look to see if there is any loose material on the crane before operating?	YES ☐ NO ☐	
3. Does he know how to oil and grease a crane properly?	YES ☐ NO ☐	
4. Does he use right type of oil in cellar boxes and in motor bearings?	YES ☐ NO ☐	
5. Does he check all controls to see if they are in the "OFF" position before closing switch to operate crane?	YES ☐ NO ☐	
6. Can he take the swing out of a hook block?	YES ☐ NO ☐	
7. Does he center the hook block before raising the lift off the ground?	YES ☐ NO ☐	
8. Does he pull the main switch when leaving the crane?	YES ☐ NO ☐	

AFTER THE ABOVE ITEMS HAVE BEEN CHECKED, PROCEED TO THE CRANE ON WHICH THE OPERATOR BEING EXAMINED WAS TRAINED TO SEE IF HE CAN OPERATE THAT CRANE.

1. Does he know how to properly operate a crane?	YES ☐ NO ☐	

DID HE PASS THE TEST? YES ☐ NO ☐

CRANE EXAMINER

Figure 17 — This check list is helpful in examination of crane operators.

sitates that the crane not be moved or bumped, temporary runway bumpers must be installed and red lights strung up to warn away adjacent cranes. Other rules prohibit by-passing of limit switches, use of toxic solvents for cleaning, and similar unsafe acts.

Many rules pertain to safety equipment. Safety equipment furnished includes such items as electrical circuit testers, hard hats, falling-material signs, blue flags, rubber gloves, burning gloves, goggles, safety belts, respirators, portable runway bumpers and red lights.

Another important phase of safety for maintenance men is the regular practice of investigating every accident, whether lost-time or merely a near-accident.

Figure 15 shows a condition existing on a crane at a sintering plant which caused a fatal accident. Even though a regular approach existed for this crane, investigation disclosed that operators and maintenance men were not using it but were crawling onto the end-truck through an opening in the building and had to cross the narrow end-truck top-plate which was always covered with flue dust. The hazard was eliminated as shown on Figure 16.

A discussion of safety would not be complete without mention of the safety department. This general plant department does much for the crane maintenance man through its literature, bulletins, participation in safety meetings, accident investigation, inspection of various maintenance jobs and general help in all safety work pertaining to maintenance.

ASSOCIATED FUNCTIONS

In addition to the many items already mentioned which have a direct bearing on preventive crane maintenance, there are four other aspects which we will call associated functions which have a definite relationship to the topic.

The first of these is crane-operator training. Poor operators are unsafe for personnel and abusive to equipment. Even supposedly good operators may be abusive on occasion, especially if encouraged by supervision.

Examples of such abuse are the use of a magnet as a demolition ball, and burning out motors which run away while lowering excessively heavy overloads.

It is generally felt that in addition to the normal disciplinary measures, the best approach to this problem is through crane operator training.

Under the formal program, a candidate is tentatively selected by the operating department and sent to the medical department for a physical examination. If he passes, he is given a minimum of 72 hours of instruction by an experienced operator.

He then is sent to the crane operator examiner, who gives him a thorough examination on rules, operating procedure and safety. The check list for this examination is shown on Figure 17. If he qualifies, he is sent to the employment office where a crane operator's brass check, Figure 18, is issued and a permanent record made.

An operator so trained will not only be less likely to abuse a crane through ignorance, but will be a first line of defense against overloading and similar abuse by ground personnel, with consequent increased safety to all concerned.

Figure 18 — A qualified crane man is given an operator's check.

Figure 19 — Maintenance areas can be kept in excellent condition through proper housekeeping.

The second of these associated items is cooperation between the operating and crane maintenance departments. This is essential for many purposes, including flow of information on breakdowns and delays, for planning and scheduling of lubrication and maintenance periods on cranes, for the planning and scheduling of major repair jobs, for investigation and prevention of abuse, for the provision of proper working and storage facilities, and for mutual aid all along the line. Without this cooperation, preventive crane maintenance is impossible.

The third associated item is maintenance of buildings and runways. In addition to regular wear and tear, and abuse, cranes are quite severely and frequently damaged by poor buildings and runways. If runways are part of the building, and the building loosens up to permit a change in crane runway span, excessive wheel wear, misalinement, twisting, and binding will result. If the roof leaks, rain and snow will cause skidding, skewing, and collector troubles. Electrical and corrosion damage probably will occur. If the runway rails, columns, or girders are bad, shock and span changes will play havoc with wheels, anti-friction and plain bearings, and will generally shake loose the whole crane, in addition to causing excessive operator fatigue.

Runway and building maintenance also includes crane access platforms and maintenance platforms. As pointed out in one of the accident examples previously discussed, poor or makeshift access facilities can be fatal. A periodic inspection of such stairways and platforms is highly recommended.

Runway and building maintenance may be successfully handled through a regular maintenance organization set up for that purpose, complete with inspectors, systematic scheduling and planning, card records, and facilities for obtaining necessary funds, equipment, material, and personnel to do the work.

The fourth and last associated function is good housekeeping. This applies to the plant, the department, and the unit. It is obvious to anyone that men can work better, faster, and safer in a clean and uncluttered area. While a crane admittedly cannot be kept immaculate, especially in areas like a sintering plant or an open hearth, it certainly can be cleaned frequently and kept free of *longtime* accumulations of dirt and grease. Working areas under cranes can also be kept reasonably safe and open by the same procedure.

Shop areas can be kept in excellent condition with little effort after the original set-up is made. Figure 19 shows the interior of a crane maintenance shop in an open hearth, with a place for everything and everything in its place.

General plant housekeeping will not only keep the men safe on their way to work, and provide safe thoroughfare for the flow of men and material to the job, but will also provide the proper psychological incentive to the men to make them think and work in terms of good housekeeping.

SUMMARY

Summarizing, preventive crane maintenance is essentially a process to eliminate unscheduled downtime and excessive deterioration of cranes.

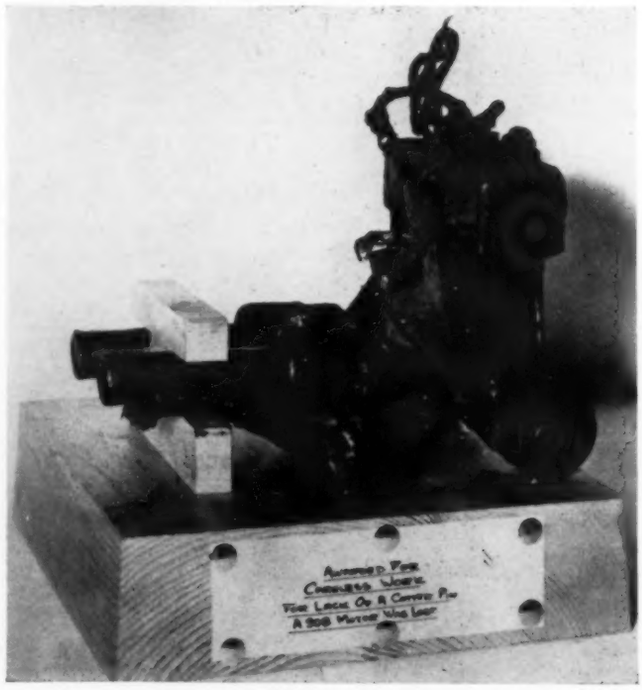
It is vitally necessary due to the large number, great importance, and extreme potential safety hazard of cranes in steel plant operations.

The complete picture of preventive crane maintenance includes engineering, erection and testing, organization, methods, and a number of associated functions.

An oldtime friend and a fine crane maintenance man once stated that "An ounce of preventive maintenance is worth a pound of repairs". This is exemplified by Figure 20 which shows a motor brush-holder which caused the total loss of a large motor due to lack of a cotter pin.

Another familiar idiom states that "A stitch in time saves nine". We might say, "A stitch in time is not much good if the other nine are ready to let go, too". Preventive crane maintenance will eliminate accidents, reduce costs, and increase production by keeping all ten stitches in good shape. A lot of it should be used on cranes.

Figure 20 — The loss of a cotter pin resulted in the total loss of a large motor.



By E. B. FITZGERALD
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Industrial Control Sales
and
ERIC PELL
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Figure 1 — General view of 38-in. blooming mill whose performance was markedly improved with new electrical control.

improved mill performance through MODERNIZED ELECTRICAL CONTROL

. . . . improvement of performance of mill drive equipment can often be accomplished through the study and modernization of the electrical controls for such equipment . . . .

▲ THROUGHOUT the years, the steel industry has compiled a most enviable record in achieving an ever-increasing productive capacity and an ever-improving product quality. Both of these two achievements may be attributed to a very rapid rate of technological advancement within the steel industry. This rapid technological advancement has in turn been fostered by active competition between the steel producing companies, and between the companies that supply this industry. In addition, a large share of credit may be given to organizations, such as the Association of Iron & Steel Engineers, who make possible the interchange of ideas and experiences between the industries' members.

Technological advancement within the steel industry has taken the form of new methods, new processes, and new machines; all designed to produce higher quality product at lower production costs. However, the simple introduction of new equipment does not entirely fulfill the requirements of complete technological advancement. With each new installation of high capacity, high quality facilities—the steel industry, and its individual operating companies, is faced with the problem of producing a product of comparable cost and quality on equipment that has been installed and operating for many years, and which often does not possess all of the modern features of the newer facilities.

At the present time the steel producing companies of the United States own plants and equipment valued at approximately $9,000,000,000. Obviously, it is impractical to discard all of this existing equipment to meet the challenge of new processes, methods, and machines. Common sense and good business judgment dictate the maintenance in service of these facilities so long as they remain commercially and physically operable, or the rejuvenation of this equipment to achieve performance comparable to new facilities. It is with this latter subject—the modernization of existing facilities—that this paper is concerned.

In reviewing the capabilities and characteristics of existing machinery, it will, in some cases, naturally be found that certain older machines, due to either extreme physical deterioration or obsolescence caused by technological pressures, are completely incapable of economical modernization, and in these cases com-

plete replacement is dictated. However, in the majority of cases a detailed study of the installation will indicate the possibility of modernizing the equipment through a relatively low cost renovation. In modernizing this equipment, the principal aim is to obtain the maximum performance improvement at the minimum financial cost. Therefore, when considering equipment modernization, an economical modernization plan should involve the utilization of the maximum possible amount of existing equipment, and a conversion schedule that requires the minimum "down time" of the operating facilities.

A review of the history of mill equipment reveals that—the great technological advancement in these facilities has been brought about, not so much in the basic design of the mechanical equipment or of the electrical driving machinery, but rather has occurred in the systems by which these two factors are coordinated and regulated, or, in other words, in their control. It should not be inferred that mechanical equipment and electrical machines have not experienced great technological strides over the years, but even greater strides have been taken in the design of the electrical systems that coordinate and regulate the operation of this equipment.

An out-moded electrical controller is often responsible for many operational characteristics of equipment which are not ordinarily directly associated with the controller. Not only can an obsolete controller be responsible for sluggish operation of equipment and hence low production rates, but it can also subject the equipment to undue mechanical or electrical stresses during operation, thus causing excessive maintenance or "down time," and in other cases can actually adversely affect product quality through inconsistent operation. Another factor, favoring modernization through conversion of the electrical control, is that the greatest portion of the financial investment in mill equipment is in the mechanical and electrical driving machinery. Hence, modernization of the electrical control can usually be made at a much lower cost than modernization of either of the other two factors.

To best illustrate how improved mill performance can be achieved through modernized electrical control, the example of one forward looking steel company who modernized the operation of a blooming mill through a very simple and low cost conversion of its electrical control will be described.

The 38-in. blooming mill, shown in Figure 1, was built in 1928 and designed for aluminum rolling service. In 1950 this mill was purchased and transferred to a steel plant in Ohio to roll steel slabs. This conversion to steel rolling service with its inherent increase in required rolling horsepower brought immediate problems. Mill reversal was sluggish, and the tremendous slab impact current inrush caused very unsatisfactory commutation of the d-c electrical machinery. As a matter of fact, a few flash-overs of the d-c generators during a day's run was almost a rule rather than exception, and "the down" or maintenance time of the mill for mechanical and electrical reasons curtailed planned production rates. An investigation was therefore instituted to study means of improving the performance of this mill. The original electrical installation of this mill is illustrated in Figure 2. The 5000-hp main d-c driving motor was supported by two parallel connected, 2000-kw, 600-volt, d-c, adjustable voltage generators. Load balance between these two generators was achieved through cross-connected series fields. The shunt fields of the adjustable voltage generators were series excited by a 32½-kw constant potential d-c exciter. Rheostatic control of the generator voltage was provided by two accelerating relays in the armature circuit of the generator field exciter, which were controlled by the position of the operator's master switch.

Excitation of the shunt field of the 5000-hp motor was provided by a 75-kw two-field adjustable voltage exciter. The main field circuit of this exciter contained

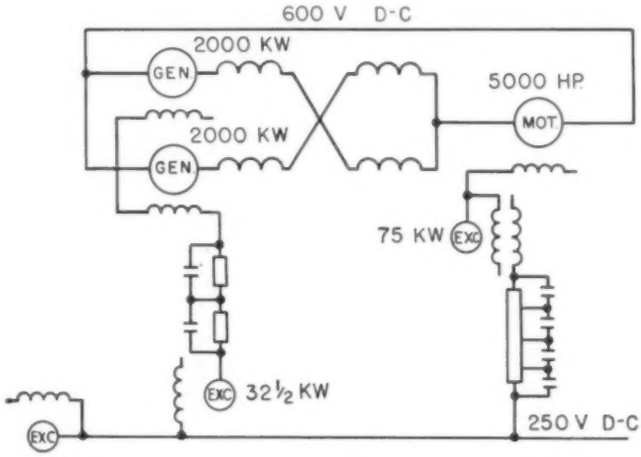


Figure 2 — Original electrical installation on 5000-hp blooming mill.

four steps of resistor commutating relays to achieve motor field weakening. The amount of motor field weakening was controlled by the position of the operator's master switch, but was limited in the rate of application by current relays in the main armature circuit. The auxiliary shunt field of the motor field exciter provided a positive feed-back circuit to the exciter so as to provide forcing action during changes in motor field excitation. Thus, the original electrical installation involved the use of an extremely simple electrical circuit, but one that was indicative of contemporary practice.

Figure 3 illustrates a graphic ammeter chart of the first ten passes of a typical 17-pass rolling schedule of this mill, prior to its modernization. In this chart the cross-hatched areas represent accelerating current inrushes and the shaded areas impact-current inrushes. A study of this chart reveals several of the causes of the problems encountered in the operation of the mill. As you will note, the impact-current inrush on the early passes approaches 17,000 amp or 260 per cent of rated generator current. The average impact-current inrush is about 13,000 amp or 200 per cent of generator rating. More important, the slope of the impact-current inrush curve is extremely steep, producing rates of armature current change on the order of 100,000 amp a second, as will be shown later.

In addition to the impact-inrushes, it is apparent

that the rheostatic type of control causes three separate accelerating inrushes upon each mill reversal, instead of a smooth single accelerating inrush as could be provided with modern regulating equipment. This series of three individual inrushes means that on each mill reversal, the mechanical and electrical equipment is subjected to three separate sets of electrical and mechanical stresses, which naturally contributed to increased maintenance requirements.

The fact that mill reversal is sluggish and not comparable to the reversal time of the associated mill auxiliaries is apparent from the fact that on passes 1, 3, 6 and 10, slab impact occurs during the last accelerating inrush, indicating that the slab re-enters the mill prior to the mill having reaccelerated to base operating speed. Figure 4, a graphic tachometer chart of a typical mill reversal, shows that the reversal time is approximately five seconds, which is extremely slow compared to modern design standards.

An analysis of these charts and the characteristics of the generators and the load indicated the principal cause of generator flash-over to stem from the rapid rate of armature current change on impact of the slab in the mill. The calculated average rate of change was in excess of 100,000 amp a second whereas the generators which were designed and built in 1928, were reported by the generator manufacturer to be limited to a rate of armature current change of only 65,000 amp a second.

Earlier in the paper, we stated one criterion of economical equipment modernization to be the maximum utilization of existing equipment, and, therefore, since these generators comprised a large portion of the total investment in the mill, it was desirable to find a means to reduce this rate of current change to within the limits of these machines. A review of the electrical characteristics of these generators also revealed that no economically feasible generator voltage regulator could be applied that would limit the rate of current change under impact to 65,000 amp a second. It was, therefore, necessary to search for some other means by which this rate of current change could be reduced. One solution considered was the effect of armature loop resistance upon the rate of impact current change.

From a knowledge of the electrical time-constant of the armature loop circuit, as well as the mechanical time-constant of the mill with its drive motor, a determination was made of the armature current and speed drop on impact as a function of armature loop resistance. This relationship, as shown in Figure 5, is based upon an impact-torque of twice rated motor torque, which is the condition previously indicated encountered on this mill.

Point A, on the curve, represents the original relationship of the mill with an armature loop resistance of 0.008 ohms and a rate of impact-current change of 101,200 amp a second. Since design limitations of the mill generators permitted a maximum rate of armature current change of only 65,000 amp a second, we trace along the 65,000 amp coordinate until we intercept our calculated curve at point B. Point B, indicates that if we wish to limit the maximum rate of generator current change to 65,000 amp a second the armature circuit should contain a total resistance of 0.015 ohms or 0.007 ohms in addition to the existing armature resistance of 0.008 ohms.

This indicated that a possible solution to the generator flash over problem would be the introduction of a permanent step of resistor in the armature circuit. The greater motor speed drop on impact obtained with this resistor results in a liberation or absorption of more kinetic energy by the rotating machinery, and thus lower rate of change in impact current, but also in a greater dissipation of power in the form of heat in this resistor. However, the extra power consumption in this case was deemed negligible in comparison to the savings in maintenance and production time that could be achieved by the elimination of generator flash-overs.

Calculated time response of the current and speed, with and without additional armature resistor, on impact, is shown in Figure 6. The dotted lines indicate the rise of armature current and drop of motor speed on impact for the original electrical installation. The solid lines indicate the same two characteristics after the addition of a 0.007 ohm resistor into the armature circuit. Note that with the addition of the armature resistor, the rise of armature current under impact is

Figure 3 — Graphic ammeter chart of typical pass schedule with original electrical equipment shows high peak values of current.

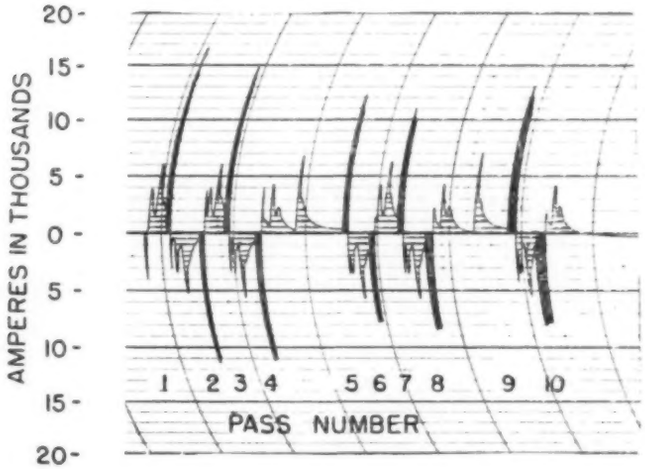
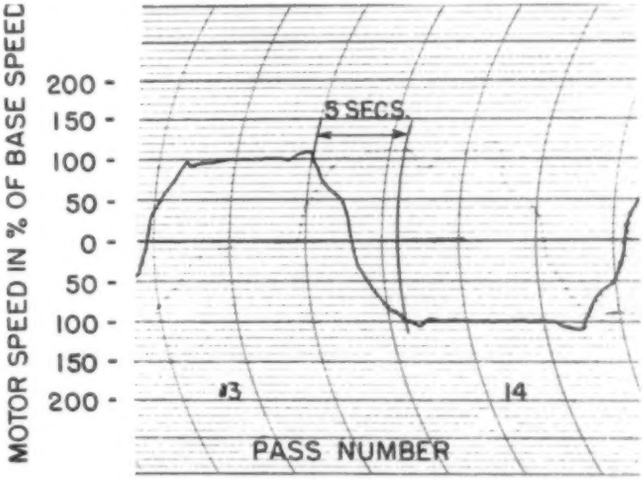


Figure 4 — Graphic tachometer chart of typical mill reversal with original electrical equipment shows sluggish operation.



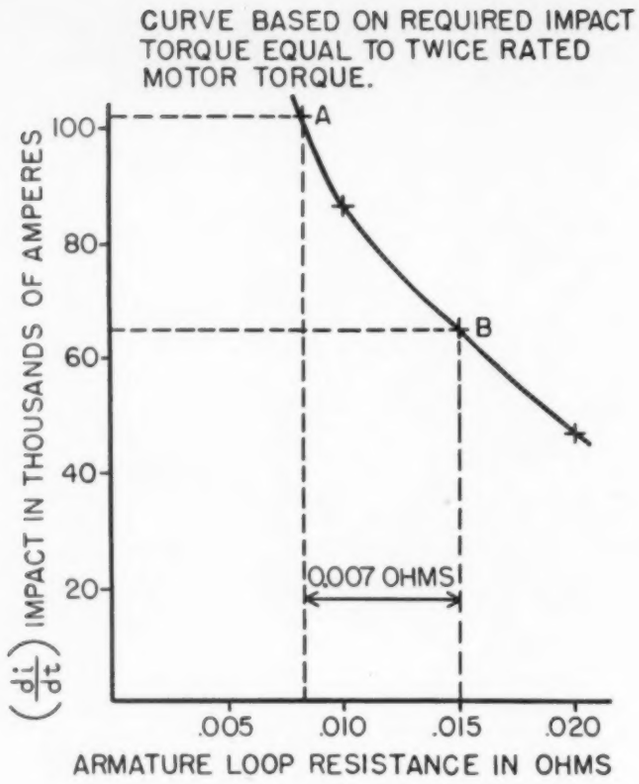


Figure 5 — Effect of armature resistance on rate of impact current change. Data gives information needed to limit rate of current change.

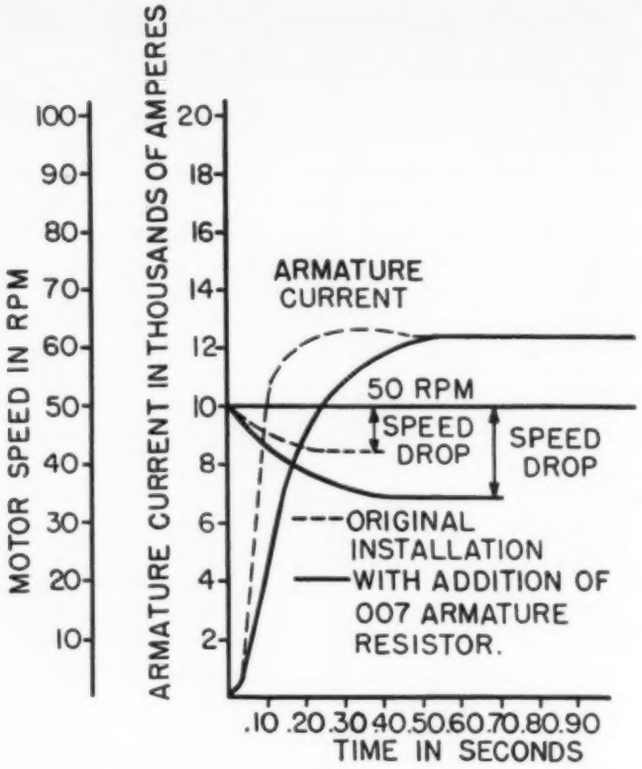


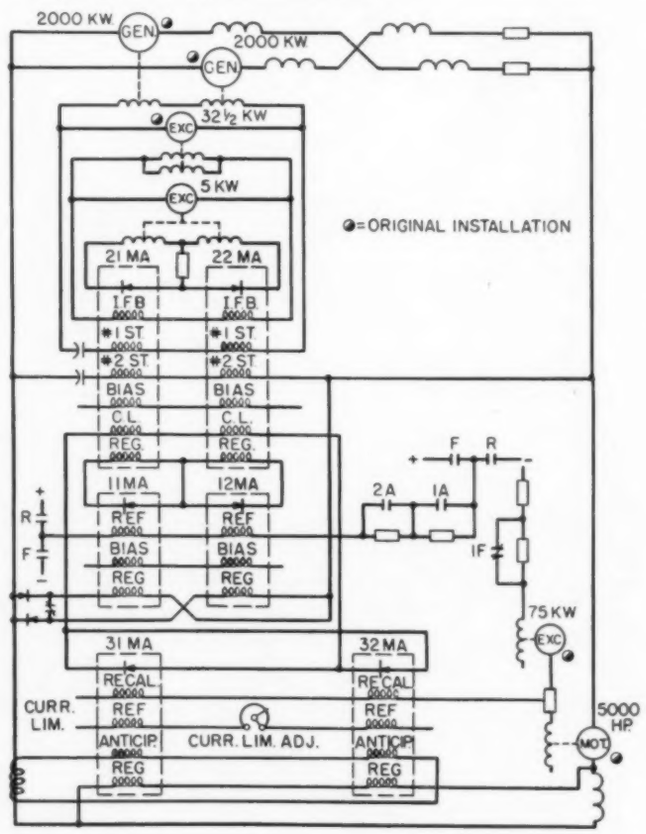
Figure 6 — Addition of permanent armature resistor gave better performance.

much less rapid than previously, but that the impact-speed drop of the motor is greater. The speed drop is greater due to reduction in motor armature voltage caused by an increased ohmic drop in the loop circuit. The amount of additional kinetic energy contributed by the mill and the mill motor during impact, with the addition of this armature circuit resistor, is indicated by the area between the dotted and solid armature current curves.

After absorbing the beneficial affect of the additional speed drop, it is of course, desirable to restore the mill speed as quickly as possible. This would call for a speed or voltage regulator with an ample margin of forcing. The modernized control circuit for this mill thus developed through this study is shown in Figure 7, and includes a voltage regulator with current limit protection.

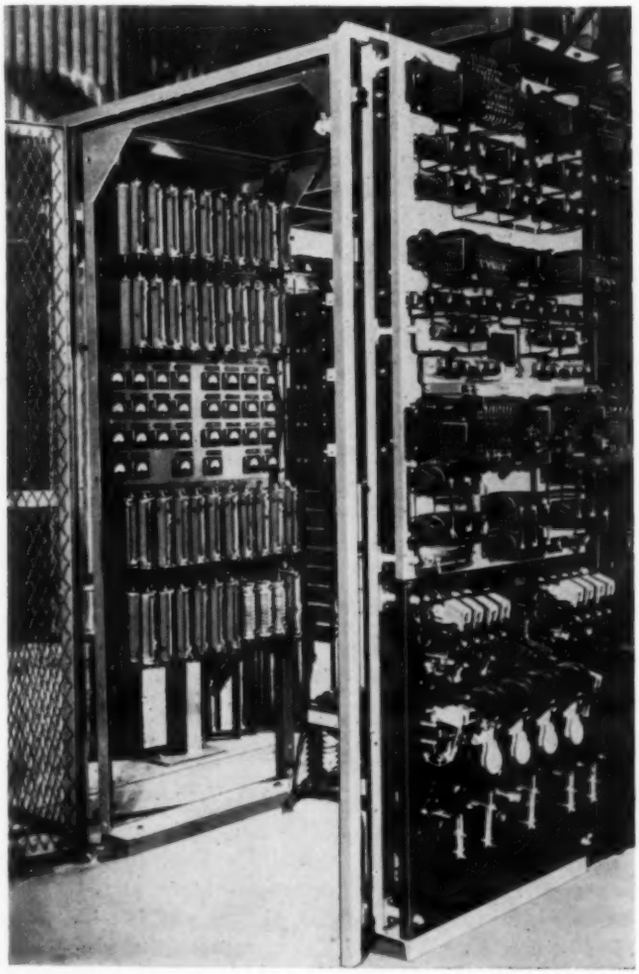
The first point to note in the revised electrical installation is the maximum utilization of existing electrical machines. The original generators, mill motor, generator exciter and motor field exciter are still in service in their original condition. The series connected field windings of the generator field exciter, however, have been reconnected in parallel to speed up the electrical response of the machine. The only new electrical equipment added is the armature resistor in the main generator loop circuit, the magnetic amplifier generator voltage regulator and a small 5-kw d-c exciter motor-generator set which serves as a reversible output stage for the magnetic amplifier regulator. It should be noted that all of this new equipment could be installed and almost completely wired prior to mill shutdown for changeover. Thus, the out-of-service time for changeover is kept to an absolute minimum, which satisfies another criterion for economical mill modernization.

Figure 7 — Modernized electrical control circuit as finally used in 5000-hp blooming mill.



Examining in more detail the operation of the magnetic amplifier voltage regulator, note that the regulator consists of two magnetic amplifiers connected back to back that control the shunt field of the 5-kw, d-c exciter in a push-pull fashion, and by this means the non-reversible feature of the magnetic amplifier regulator is accommodated. The reversing and accelerating relays, controlled by the position of the operator's master, previously connected directly in the generator field circuit, are now placed in the reference field circuit of this regulator. In the regulator, this signal is combined with the inverse feed-back from the field circuit of the generator field exciter, and the stabilizing signals obtained from the armature circuit of the generator field exciter and from the main generator armature circuit so as to produce the desired regulator output for control of the generator armature voltage. Current limit control is provided by two separate magnetic amplifiers that obtain a current signal across the series winding of the main driving motor, and a reference signal from the current limit adjustment rheostat. The current limit signal thus developed in these amplifiers is fed to the control fields on the main magnetic amplifier voltage regulator. Figure 8 shows the control panel furnished for this electrical modernization that mounts the magnetic amplifier voltage regulator and its associated equipment. This panel, which is only 32-in. in width, is of the self-supporting type and is designed to dimensionally match the existing control panels. The permanent armature resistor for the main adjustable voltage loop circuit is shown in Figure 9. Forced ventilation of the resistor is used to reduce the amount of resistor material required.

Figure 8 — This magnetic amplifier voltage regulator panel was furnished for 5000-hp blooming mill.



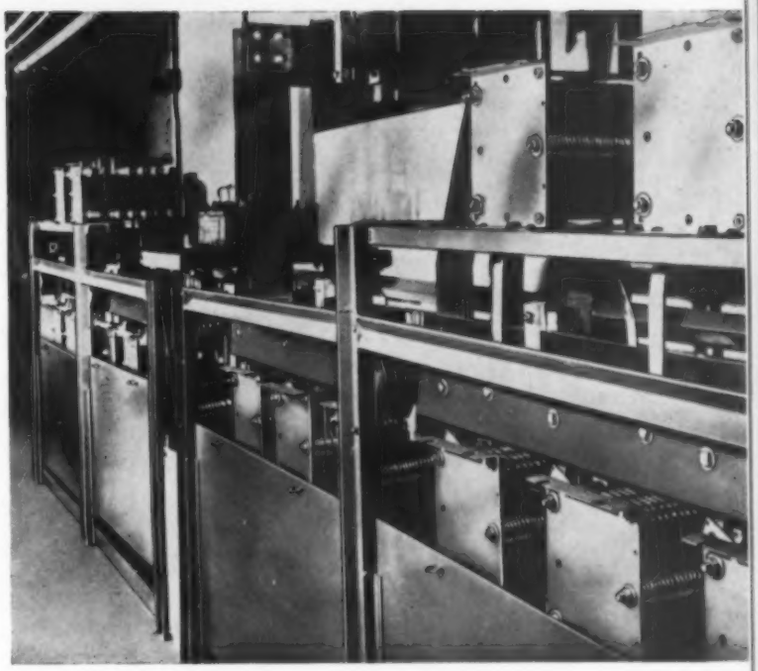


Figure 9 — A permanent armature circuit resistor was built for 5000-hp blooming mill.

Figure 10 is a graphic ammeter chart of the first 12 passes of a typical rolling schedule of this blooming mill after modernization of its electrical control. Again,

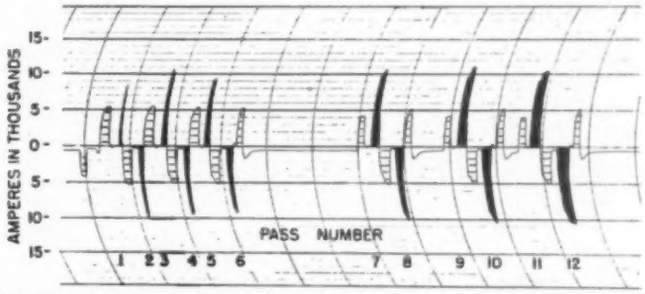
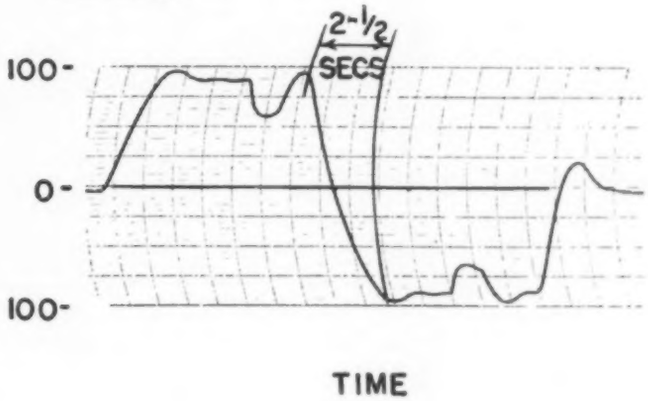


Figure 10 — Graphic ammeter chart of typical pass schedule with modernized electrical control shows lower current peaks.

Figure 11 — Graphic chart of typical mill reversal with modernized electrical control shows time cut in half. The ordinate of this chart is per cent of motor terminal base voltage.



as in Figure 3, the shaded areas indicate impact-current inrushes; the cross-hatched areas, accelerating inrushes. The principal improvement in the operation of this mill, gained by the modernization of the electrical control equipment, has been the elimination of generator flash-over through a reduction in the rate of armature current change during impact. Although it is not too apparent from Figure 10, the slope of the impact current curve has been considerably reduced. However, two other improvements in the operation of this mill are readily apparent from this ammeter chart. The three individual accelerating inrushes have been replaced by a single inrush, which is a product of the current limit control of the magnetic amplifier generator voltage regulator. Instead of three sets of electrical or mechanical stresses imposed upon the equipment, on each acceleration or reversal, there is now only one. Also, note the slab no longer re-enters the mill during the acceleration current inrush. This therefore means that the mill is able to reverse and completely reaccelerate to base speed prior to the time that the auxiliary equipment is able to re-insert the slab. The forcing action of the generator voltage regulator is responsible for this improved mill reversal time.

Figure 11, a graphic chart of mill motor armature voltage during a typical mill reversal, reveals that the mill reversal time has been cut one-half, from five seconds to only 2½ seconds. You will also note from Figure 11 that impact-speed drop occurs well after completion of mill reversal. This indicates that either the auxiliary equipment is not capable of returning the slab to the mill as quickly as the mill is able to receive it, or that the mill operators are not as yet familiar with the new operating characteristics of the mill. If the mill auxiliary equipment is not now able to keep pace with the mill, a further study is indicated to determine if an economical modernization could be made of the mill tables and other auxiliaries to reduce the reversal time of the slab, and thereby substantially increase the mill production rate.

In summary, we have reviewed one typical application by which the operating characteristics, of an outmoded piece of mill equipment, have been substantially improved through a very low-cost modernization of its electrical control. In this particular instance, we have dealt with one specific 38-in. blooming mill, and we have improved its performance principally through decreasing its maintenance and out-of-service time. We obtained a slight increase in the production rate of the equipment and have determined certain additional steps that could be taken to further increase its production rate. The real importance of this study, however, has not been the fact that we were able to modernize this one specific blooming mill. It is, instead, our hope that this example will reveal to other mill operators the possibility of modernizing all types of outdated mill equipment through intelligent modernization of the equipment's electrical control. In order to meet the challenge of high product quality and low production cost offered by new high capacity mill equipment, steps such as outlined in this paper must be considered for the rejuvenation of older existing facilities.

DISCUSSION

PRESENTED BY

J. H. HOPPER, Manager-Steel Mill Requisition Engineers, General Electric Co., Industrial Engineering Department, Steel Mill Section, Schenectady, N. Y.

ERIC PELL, Engineering Supervisor, Cutler-Hammer, Inc., Inc., Milwaukee, Wisc.

J. H. Hopper: I would like to compliment Mr. Fitzgerald and Mr. Pell on a very fine paper, and one which calls attention to many facts with which we are heartily in agreement. For example, we certainly agree that the first place to look for possibilities of improving performance on old drives is in replacing or modernizing obsolete control equipment. Very likely that is where the most improvement can be obtained per dollar invested.

There are, however, a number of questions to which the owner of such a mill will want answers before starting in to modernize the old equipment. For example:

1. How does the mill under consideration fit in with the present plant requirements and also requirements for the foreseeable future? Will it produce adequate tonnage? Is it properly located with regard to future plans for plant expansion? Can it compete with a completely new and larger mill when considering all factors, such as cost per ton, product quality, and down time for maintenance?
2. What is the condition of the main drive machines? Am I gambling my entire plant output on the condition of machine windings which should have been replaced years ago? How much useful life is left in the commutators? How badly have these machines been punished with overloads or high ambient temperatures, or dirty conditions?

The above is not a complete list of questions by any means, but only a sample to illustrate that it is sometimes, but not always, advisable to spend money for modernizing old mill drives.

This paper also illustrates very well the fact that there are things to look out for in the application of old second-hand electric drives. Just the fact that a motor or generator has a certain nameplate rating does not necessarily guarantee that you can get that much out of it under any and all conditions. The application of armature circuit resistors in this case made it possible to use the old drive with acceptable results. However, reference to Figure 11 of the paper, indicates that on the short passes, the motor speed was sagging to about 60 per cent of base speed during the time the metal was in the mill. Since horsepower is the product of torque and speed, the drive was only delivering 60 per cent of the horsepower of which it should be capable, or 60 per cent of the horsepower which could be obtained from a new drive of the same rating. Probably on the longer passes at lighter torques, the comparison is less unfavorable, but in any case, a significant portion of the horsepower rating of the equipment has had to be sacrificed because of the unsatisfactory transient performance of the old machines.

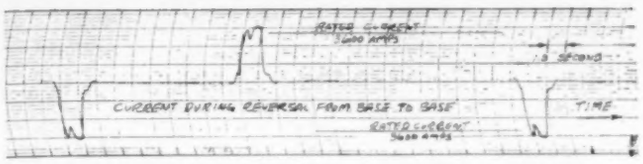


Figure 12 — Reversal in this mill takes place in about two seconds.

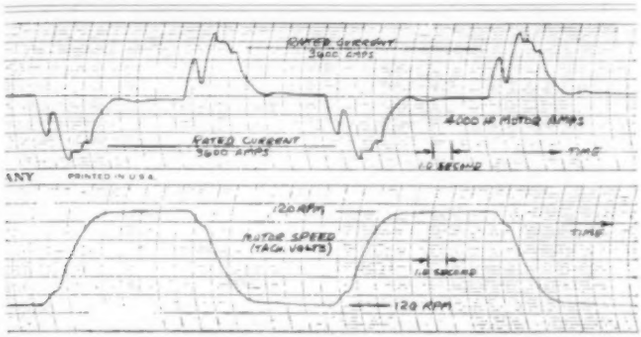


Figure 13 — Reversal from 200 per cent base speed takes place in about 3½ seconds.

I understand from the paper that only a moderate increase in tonnage from this mill was realized as a result of this modernization of the main drive control. As the authors point out, it may well be that a more significant increase in output can be realized with new mill auxiliary drives.

Our company has furnished a good many new controls for existing reversing hot mills. Fortunately, the main drive generators we have encountered have been able to commutate higher rates of change of current than those described in this paper, so we have not had to resort to armature circuit resistance as yet.

Just recently we put into operation a new control equipment for a single armature 4000-hp, 60/140-rpm universal slabbing mill for which the original equipment was furnished in 1929. The two generators were each rated 2200 kw, 900 volts, at 514 rpm. All of the original machines and the main exciter were used, but rotating regulators were furnished for the generator voltage regulator and motor field regulator. Two figures illustrate the performance of this old mill with new control. Figure 12 shows armature current only during reversals from base speed forward to base speed reverse. It will be noted that the current has returned to its minimum value within approximately 2 seconds, indicating that the reversal is complete at that time. Also, note that the reversal current is about 110 per cent of rated value, which indicates that the inertia of motor and mill is comparatively quite large. Except for this fact, the reversal could have readily been made still faster.

Figure 13 shows armature current and motor speed during several reversals from 120 rpm forward to 120 rpm reverse. It will be noted that this reversal from 200 per cent base speed is essentially complete in 3½ seconds, and that the maximum current during reversal is only approximately 125 per cent.

In closing, I would like to ask Mr. Fitzgerald or Mr. Pell two questions regarding the circuit shown as their Figure 7.

1. I was intrigued by the anticipator circuit in the current limit magnetic amplifiers 31MA and 32MA. What type of current transformer is used to obtain the required signal for rate of change of armature current?
2. Was the feedback circuit from generator voltage to the voltage regulator actually connected on the motor side of the armature circuit resistor as shown, or was it connected on the generator side? I would suspect the latter from inspection of Figure 11, because there does not seem to be much tendency for the voltage to recover during the time when the ingot is in the mill. Also with the connection as shown, I would expect considerable overshooting of voltage as the ingot leaves the mill, perhaps causing tripping of overvoltage relays.

Eric Pell: In reply to Mr. Hopper's first question, the current transformer of the anticipator circuit is of the through type with an iron cross section of 6 sq in. utilizing an air gap in the magnetic path. The size was somewhat dictated by available standard frame sizes. This circuit was included to insure a limitation imposed by the motor manufacturer on the rate of change in the accelerating current of ten times rated motor current

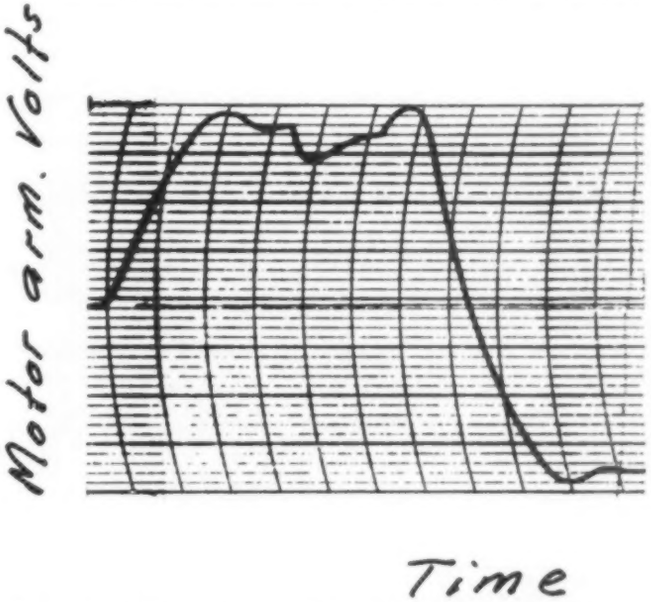
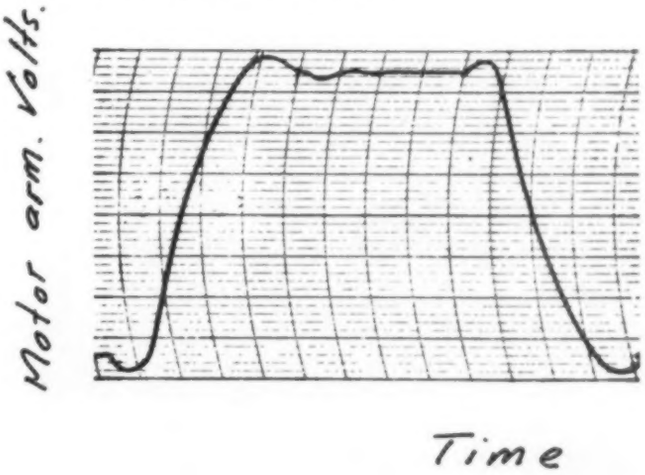


Figure 14 — Recovery time for voltage is about one second.

Figure 15 — Chart shows speed of armature voltage recovery on a longer and lighter pass.



per second. Actually, with the present calibration of this circuit, the rate of change in current on deceleration and acceleration is considerably less, and a further reduction in the reversal time could be obtained by a reduction in the effectiveness of this circuit. However, the operators of the mill prefer the smoothness of operation obtained with the present arrangement, especially since little is gained in making the mill much faster than the auxiliaries.

In reply to the second question, the voltage regulator is connected to regulate motor terminal voltage. The time required for the voltage to recover after the ingot enters the mill is of the order of one second, which, because of the short pass represented by Figure 11, is not clearly evidenced by this figure. We wish to refer to Figure 14 representing a somewhat longer pass and clearly indicating the recovery time as well as voltage overshoot as the ingot leaves the mill. Figure 15 illustrates the speed or armature voltage recovery on a still longer but lighter pass.

Member: As indicated in the opening remarks of that paper, when technical progress and new design arrangements work to obsolete the performance of existing and operating expensive drive equipment, the first consideration is normally given to the possibility of revamping. In many cases, it is found that replacement or modification of some of the least expensive equipment in an over-all installation can result in the continued competitive performance of the more expensive equipment.

In some cases of mill control equipment, replacement, an expenditure amounting to but a few per cent of the over-all initial electrical equipment investment for a mill drive, can result in a definite lowering of operating costs through greater production and lesser maintenance. In a short time, the value of the expenditure can be recovered. Certainly, today, with advances in control being what they are, revamping or replacing such old equipment can put apparent new life into relatively old mills. Particularly is this true in the case of blooming, slabbing, bar and similar mills.

That this is so, reflects much credit on main drive motors and generators made many years ago, and foretells what can be expected in the future of improved modern electrical drive apparatus.

Quite a few older reversing mills have been modified to improve their performance. Generally, older forms of contactor type control systems have been replaced by modern rotating regulator systems capable of controlled forcing action under current limiting protection up to ten times normal steady operating levels. These systems have been responsible in large measure for the fast reversal times of from one and a half seconds to less than a second on some modern mills. Further, such control systems require lesser maintenance than their forebearers, the contactor types.

Now, magnetic amplifier systems offer still greater gains because of both their performing ability and their physical attribute of being static type equipment. On primary reversing mills, such static regulators offer a relatively new means of obtaining better over-all performance.

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1956 ANNUAL CONVENTION *and* IRON AND STEEL EXPOSITION

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To

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President, AISE

September 25, 26, 27, 28 • 1956

PREVIEW

IRON AND STEEL EXPOSITION AISE ANNUAL CONVENTION

WIN A THUNDERBIRD

Approximately 14,000 persons are expected to visit the 1956 Iron and Steel Exposition, which will be held at Cleveland Public Auditorium, September 25, 26, 27 and 28, in conjunction with the Annual Convention of the Association of Iron and Steel Engineers.

Again breaking its previous records, the Iron and Steel Exposition will offer four halls full of the exhibits of some 200 suppliers to the iron and steel industry. Displayed here will be many improvements and new developments in equipment, products and services of inestimable value to the iron and steel industry in improving the economy of its operations.

Sixty authors, each an authority in his field, will present technical papers grouped into 14 sessions according to various areas of interest, and geared to the man in the plant as well as to top supervision.

This combination of activities provides a jack-pot of new ideas on many phases of the design, construction, operation and maintenance of iron and steel plants. No steel man can participate in these activities without picking up something that will help in his work.

Tickets for the 1956 Iron and Steel Exposition are being distributed throughout the iron and steel and allied industries. They may also be obtained upon request to the Association of Iron and Steel Engineers, 1010 Empire Building, Pittsburgh 22, Pa. AISE membership is not required and there is no registration fee for the Exposition or technical sessions.

HOTEL ACCOMMODATIONS

Hotel reservations should be made direct to the hotel of your choice, giving time of arrival and type of accommodations desired. Reservations should state that they are for the AISE Convention. If they are unable to take care of you, they will forward your request to the Cleveland Convention Bureau, who will place you elsewhere.

TRANSPORTATION

For those not using trains or planes and not wishing to drive, arrangements have been made with the Greyhound Bus Co. to provide charter service for groups or companies.

Also, certain of their regular runs will be designated as the "Iron and Steel Exposition Excursion." Reduced rates will be in effect for this service.

Details and rates for both services can be obtained from your local Greyhound Agent.

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Technical sessions will offer the thinking of sixty authorities on the engineering and operating of iron and steel plants.

The annual dinner, a regular feature of AISE conventions, will be held at the Hotel Statler.

PROGRAM

1956 AISE CONVENTION and IRON AND STEEL EXPOSITION

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CLEVELAND PUBLIC AUDITORIUM
CLEVELAND, OHIO

Tuesday, September 25, 1956

9:00 am — REGISTRATION — Main Lobby

9:15 am — BUSINESS MEETING — Ballroom

Conducted by President W. H. Collison

9:30 am — ELECTRICAL SESSION — Ballroom

Chairmen: Ray T. Winterringer, Assistant Superintendent Electrical Department, South Chicago Works, Republic Steel Corp., Chicago, Ill.

Richard G. Nolan, Electrical Engineer, Granite City Steel Co., Granite City, Ill.

"Electrical Equipment for Continuous Annealing of Silicon Steel Strip," by G. J. Hay, Steel Mill Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa., and Hugh S. Fegely, Control Design Engineer, Westinghouse Electric Corp., Buffalo, N. Y.

"Application of Speed Controls for Hot Strip Finishing Mills," by George S. Koss, Superintendent Plate, Slab and Strip Mill and Louis E. Ringger, General Supervisor, Electrical Engineering, Columbia-Geneva Steel Division, United States Steel Corp., Provo, Utah.

"Electrical Features of a Hot Strip Mill Reversing Rougher with Close Coupled Edger," by J. H. Greiner, Application Engineer, Electrical Application Department, and A. Mozina, Engineer, Control Section, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

9:30 am — BLAST FURNACE SESSION — Club Room B

Chairmen: J. H. Strassburger, Assistant Vice President, National Steel Corp., Pittsburgh, Pa.

George H. Greene, Assistant General Manager, Bethlehem Steel Co., Johnstown, Pa.

"Reducing Delays During the Blast Furnace Campaign Through Improvement of Mechanical Features," by W. O. Bishop, Superintendent, and Charles P. Frame, Mechanical Foreman, Plant 2 Blast Furnaces, Inland Steel Co., East Chicago, Ind.

"Automatic Split-Wind Blowing Equipment—Duquesne Works," by James S. Frazer, Jr., General Supervisor-Power and Fuel, Engineering Department, Duquesne Works, United States Steel Corp., Duquesne, Pa.

"Development of Tuyere Air Proportioning for the Blast Furnace," by E. K. Miller, Jr., Assistant Division Superintendent, Blast Furnaces, Gary Steel Works, United States Steel Corp., Gary, Ind.

2:00 pm — MECHANICAL SESSION — Club Room B

Chairmen: C. W. Bruce, Chief Engineer, Chicago District, Republic Steel Corp., Chicago, Ill.

Charles H. Good, Jr., Chief Engineer, Duquesne Works, United States Steel Corp., Duquesne, Pa.

"The Design of Mill Buildings," by J. J. Murray, Development Engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa., and Thomas C. Graham, Chief Design Draftsman, Design Engineering Department, Pittsburgh Works, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"Treatment and Reuse of Mill Scale Wastes to Conserve Water and Abate Pollution," by Grant A. Pettit, Industrial Waste Control Engineer, Armco Steel Corp., Middletown, Ohio.

"Economics of Oxygen Generating Stations for Steel Mill High and Low Purity Oxygen Applications," by Arthur E. Steele, Manager, and Donald E. Cummings, Assistant Manager, Steel Mill Sales Division, Air Products, Inc., Allentown, Pa.

2:00 pm — COMBUSTION SESSION — Ballroom

Chairmen: R. A. Lambert, Superintendent Steam & Combustion, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

David Cousley, Assistant Superintendent Utilities, Wheeling Steel Corp., Steubenville, Ohio.

"The Relative Value of Various Gases for Scarfing," by W. M. Bloom, Combustion Engineer, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

"The Prevention of Gas Incidents," by T. A. Watson, Assistant Division Superintendent, Power Production, United States Steel Corp., South Works, Chicago, Ill.

"Control of Atmosphere Generators," by R. R. Swain, Manager Iron and Steel Division, Bailey Meter Co., Cleveland, Ohio.

Wednesday, September 26, 1956

9:00 am — ELECTRICAL SESSION — Ballroom

Chairmen: F. H. Wickline, Electrical Engineer, United States Steel Corp., National Tube Division, Pittsburgh, Pa.

Ernest F. Donatic, Assistant General Supervisor, Service Division, Kaiser Steel Co., Fontana, Calif.

"Greater Flexibility for Wire Drawing," by R. C. Suttle, Reliance Electric & Engineering Co., Cleveland, Ohio, and Maurice A. Nye, Chief Engineer, The Vaughn Machinery Co., Cuyahoga Falls, Ohio.

"Electrical Maintenance at the Pueblo Plant of the Colorado Fuel & Iron Corp.," by H. E. Watson, Electrical Superintendent, The Colorado Fuel & Iron Corp., Pueblo, Colo.

"Protection of Men Exposed to the Hazards of Moving Overhead Electric Cranes," by Harold R. Miller, General Foreman Assigned Maintenance, Butler Works, Armco Steel Corp., Butler, Pa.

9:00 am — COMBUSTION SESSION — Club Room B

Chairmen: Frank C. McGough, Superintendent Power & Fuel, Detroit Steel Corp., Portsmouth Works, Portsmouth, Ohio.

H. B. Helm, Fuel Engineer, Youngstown Sheet & Tube Co., East Chicago, Ill.

Exposition and Technical Sessions are at Cleveland Public Auditorium . . . . .

"Normalizing and Heat Treating of Steel Plate," by Horace Drever, President, and N. K. Willis, Chief Engineer, Drever Co., Bethayres, Pa.

"Study of Factors Influencing Surface Staining of Cold Rolled Steel,"

Part I — "Types of Defects and Their Occurrence," by C. R. Lillie, Research Metallurgist and D. W. Levinson, Supervisor, Non-ferrous Metals Research, Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill.

Part II — "Identification and Reaction Mechanisms," by F. Schossberger, Senior Scientist, K. Hattori, Research Chemist, and H. Marver, Assistant Chemist, Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill.

"Modernization of Wheel Heating Facilities, Johnstown Plant, Bethlehem Steel Co.," by F. R. Pullen, Fuel Engineer, Bethlehem Steel Co., Johnstown, Pa.

2:00 pm — OPERATING PRACTICE SESSION — Ballroom

Chairmen: Karl L. Fetters, Asst. to Vice President-Charge Operations, Youngstown Sheet and Tube Co., Youngstown, Ohio.

S. O. Evans, Manager Tubing Operations, Babcock & Wilcox Co., Tubular Products Division, Beaver Falls, Pa.

"Nuclear Technology and the Steel Industry," by R. P. Peterson, Director Nuclear Research, Republic Steel Corp., Cleveland, Ohio.

"Transportation Control in Steelmaking," by J. L. Kerins, General Transportation Manager, Steel Operating Division, United States Steel Corp., Pittsburgh, Pa.

"Pipe: Manufacture and Use," by P. D. Thomas, Materials Engineer, Asiatic Petroleum Corp., New York, N. Y.

2:00 pm — LUBRICATION AND PAINT SESSION — Club Room B

Chairmen: Donald E. Whitehead, General Lubrication Engineer, Crucible Steel Co. of America, Pittsburgh, Pa.

Charles T. Lewis, Chief Lubrication Engineer, Republic Steel Corp., Cleveland, Ohio.

"Solvent Degreasing — A Valuable Industrial Cleaning Process," by W. L. McCracken, Director of Research, Detrex Corp., Detroit, Mich.

"Evaluation and Specification of Paint for Industrial Use," by Joseph Bigos, Senior Fellow, Mellon Institute, and Director of Research, Steel Structures Painting Council, Pittsburgh, Pa.

"Silicone Lubricants and Protective Coatings in the Steel Industry,"

Part I — "Silicone Lubricants," by W. H. Ragborg, Laboratory Supervisor, and W. H. Badger, Development Engineer, Fluids Section, Product Development Laboratories, Dow Corning Corp., Midland, Mich.

Part II — "Silicone Protective Coatings," by R. C. Hedlund, Supervisor, Coatings Laboratory, Product Development Laboratories, Dow Corning Corp., Midland, Mich.

6:30 pm — OLD TIMERS' DINNER

Thursday, September 27, 1956

9:00 am — OPERATING PRACTICE SESSION — Ballroom

Chairmen: George L. Bottcher, Chief Engineer, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

Warren E. Hart, Superintendent Electric Furnace Building, Ford Motor Co., Rouge Plant, Dearborn, Mich.

"Experimental Results with Hollow Electrodes in Electric Steel Furnaces," by W. E. Schwabe, Product and Process Development Laboratory, National Carbon Co., Niagara Falls, N. Y.

"Economic Future of the Large Top Charge Electric Furnace," by Wm. B. Wallis, President, Lectromelt Furnace Co., A McGraw Electric Co. Division, Pittsburgh, Pa.

"Basic Hot Blast Cupola as Source of Hot Metal for Steel Plants," by E. S. Harman, President, E. S. Harman Corp., Chicago, Ill. and Siegfred Tunder, Technical Director, Gesellschaft fur Huttenwerksanlagen, Dusseldorf, Germany.

9:00 am — LUBRICATION SESSION — Club Room B

Chairmen: C. A. Bailey, Lubrication Engineer, United States Steel Co., National Tube Division, Pittsburgh, Pa.

Andrew Cichelli, Lubrication Engineer, Bethlehem Steel Corp., Construction & Engineering Department, Bethlehem, Pa.

"Measurements for the Consistency of Lubricating Greases," by Ben Holliday, Chemist, Materials Engineering Division, Crucible Steel Co., Midland, Pa.

"High Temperature Steel-Mill Greases," by John Simon, Lubrication Engineer, National Works, National Tube Division, United States Steel Corp., McKeesport, Pa.

"Stopping Corrosion by the Use of Rust Preventive Compounds," by R. P. Mills, Manager, Rust Preventive Division, Valvoline Oil Co., Division Ashland Oil and Refining Co., Freedom, Pa.

7:00 pm — FORMAL DINNER AND DANCE — Ballroom

Norman Lewis will give a humorous talk called "The Kick in Life."

Friday, September 28, 1956

9:00 am — ROLLING MILL SESSION — Ballroom

Chairmen: C. S. Lambert, Superintendent, Merchant Mills, Campbell Works Youngstown Sheet and Tube Co., Youngstown, Ohio.

Don C. Horsman, Assistant General Superintendent, Continental Steel Corp., Kokomo, Ind.

"Seamless Tube Making by the Calmes Process," by Dr. Albert Calmes, Albert Calmes & Co., Milan, Italy, and Clyde Roberts, Chief Engineer, Phoenix Iron and Steel Co., Phoenixville, Pa.

"Backup Rolls and Their Contribution to Gage Variation," by Earl G. Lindsey, General Foreman-Roll Shop, Cold Reduction Department, Sheet and Tin Mill, Columbia-Geneva Steel Division, United States Steel Corp., Pittsburg, Calif.

"Weirton Modernizes Its Hot Mill," by L. A. Fugassi, Assistant Chief Engineer, Weirton Steel Co., Weirton, W. Va.

9:00 am — COMBUSTION SESSION — Club Room B

Chairmen: F. Bruce Bevelheimer, Power & Fuel Engineer, Ford Motor Co., Steel Division, Rouge Plant, Dearborn, Mich.

George H. Krapf, Division Superintendent, Power Production, United States Steel Corp., South Works, Chicago, Ill.

"An Automatic System of Fuel Control," by D. R. Mathews, Open Hearth Superintendent, Alan Wood Steel Co., Conshohocken, Pa.

"Modifications to the Fontana Open Hearth Precipitators," by E. V. Akerlow, Assistant Division Manager, Kaiser Engineers, Steel Division, Oakland, Calif.

"The All-Basic Open Hearth Furnace," by R. P. Heuer, Vice President, and M. A. Fay, Assistant General Sales Manager, General Refractories Co., Philadelphia, Pa.

. . . . . Social Functions are at Hotel Statler

2:00 pm — ELECTRICAL SESSION — Ballroom

Chairmen: Robert T. Lucas, Electrical Superintendent, Weirton Steel Co., Weirton, W. Va.

Clayton L. Squier, Assistant Superintendent, Electrical Department, Bethlehem Steel Corp., Lackawanna, N. Y.

"Roughing Motor Inching Drives," by Dr. Roger Shields, Development Engineering Department, Elliott Co., Jeannette, Pa. and H. Kermit Fish, Assistant Electrical Superintendent, Weirton Steel Co., Weirton, W. Va.

"Automatic Gage Control for Cold Reduction Mills," by R. A. Phillips, Analytical Engineering Section, and H. S. Maxwell, Steel Mills Systems Application Engineering Section, General Electric Co., Schenectady, N. Y.

"Automatic Gage Control and Production Analysis on a 'Z' Mill," by J. W. Hopper, Jr., Gage Application Engineer, Pratt & Whitney Co., West Hartford, Conn.

2:00 pm — OPERATING PRACTICE SESSION — Club Room B

Chairmen: H. R. Knust, Assistant to General Manager, Bethlehem Steel Co., Baltimore, Md.

H. A. Long, Chief Engineer, Pittsburgh Steel Co., Monessen, Pa.

"Basic Data on Mechanical Cleaning Operations in Steel Plants," By Gilbert D. Dill, Engineer in charge of Steel Division, Wheelabrator Corp., Mishawaka, Ind.

"Automation and its Tooling and the Concept used at Inland Steel Co.'s New Rail Joint Line," by C. E. Chapman, Superintendent, Rail Accessories Department, Inland Steel Co., Indiana Harbor Works, East Chicago, Ind.

"Edge Position Control for the Steel Strip Industry," by Frank J Markey, Manager, Edge Position Controls Division, Askania Regulator Co., Chicago, Ill.

IRON AND STEEL EXPOSITION HOURS

SEPTEMBER 25—TUESDAY . . . . . 10:00 A.M. TO 10:00 P.M.
SEPTEMBER 26—WEDNESDAY . . . . . 10:00 A.M. TO 10:00 P.M.
SEPTEMBER 27—THURSDAY . . . . . 10:00 A.M. TO 5:00 P.M.
SEPTEMBER 28—FRIDAY . . . . . 10:00 A.M. TO 4:00 P.M.

LADIES PROGRAM

HEADQUARTERS • PARLOR E • HOTEL STATLER

Tuesday, September 25, 1956

9:00 am — LADIES REGISTRATION — Parlor E, Hotel Statler

12:30 pm — SOCIAL HOUR — Pine Room, Hotel Statler

1:15 pm — LUNCHEON — Euclid Ball Room, Hotel Statler

Wednesday, September 26, 1956

12:30 pm — LUNCHEON — Higbee's Lounge

The Higbee Co. is located on Public Square

Thursday, September 27, 1956

9:00 to 11:00 am — KAFFEE KLATSCH — Parlor E, Hotel Statler

7:00 pm — FORMAL DINNER — Ball Rooms, Hotel Statler

10:00 pm — DANCE — Euclid Ball Room, Hotel Statler

Honorary Chairman — Mrs. W. H. Collison

General Chairman — Mrs.Richard H. Cox

Vice Chairman — Mrs. Floyd Garman

To partially cover the cost of ladies activities, a flat charge of $5.00 will be made, covering everything except the formal dinner. This must be paid on registering, when tickets will be issued for the various events.

IRON AND STEEL EXPOSITION

LIST OF EXHIBITORS

A

Acetogen Gas Co.
Adalet Manufacturing Co.
Air Reduction Sales Co.
Ajax Flexible Coupling Co., Inc.
Alemite Division, Stewart-Warner Corp.
Allen-Bradley Co.
Alliance Machine Co.
Louis Allis Co.
Allis-Chalmers Manufacturing Co.
American Air Filter Co., Inc.
American Brake Shoe Co.
American Ferrox Corp.
Ampco Metal, Inc.
Anaconda Wire and Cable Co.
Appleton Electric Co.
Askania Regulator Co.
Automatic Transportation Co.

B

Bailey Meter Co.
Bearing Service Co.
Beckman, Inc., Arnold O.
Blaw-Knox Co.
Bliss Co., E. W.
Bloom Engineering Co., Inc.
Brown Fintube Co.

C

C & D Batteries, Inc.
Chromium Corporation of America
Cities Service Petroleum, Inc.
Clark Controller Co.
Cleveland Engineering Society.
Cleveland Worm and Gear Co.
Cone-Drive Gears, Division of Michigan Tool Co.
Cooper Split Roller Bearing Corp.
Crouse-Hinds Co.
Cunningham Co., M. E.
Cuno Engineering Corp.
Curry Air Shear Corp.
Cutler-Hammer, Inc.

D

Delpark Corp.
Detrick Co., M. H.
Dravo Corp.

E

Electric Controller & Mfg. Co., Division of Square D Co.
Electric Furnace Co.
Electric Products Co.
Electric Service Manufacturing Co.
Electric Storage Battery Co., Exide Industrial Division
Elliott Co.
Elwell-Parker Electric Co.
Enterprise Co.
Euclid Electric & Mfg. Co.

F

Fabreeka Products Co.
Farval Corp.
Federal Pacific Electric Co.
Femco, Inc.
Foote Bros. Gear and Machine Corp.
Foxboro Co.

G

Gear Grinding Machine Co.
General Electric Co., Apparatus Sales Division
General Electric Co., Distribution Assemblies Department
General Electric Co., Trumbull Components Department
Gleason Reel Corp.
Gould-National Batteries, Inc., Industrial Division
Gulf Oil Corp.

H

Hagan Corp.
Harnischfeger Corp.
Heil Process Equipment Corp.
Heyl & Patterson, Inc.
Holophane Co., Inc.
Homestead Valve Manufacturing Co.
Houghton & Co., E. F.
Hunt & Son, Inc., C. B.
Hyatt Bearings Division, General Motors Corp.
Hyde Park Foundry & Machine Co.

I

Ideal Industries, Inc.
Industrial Filtration Co.
Industrial Gear Mfg. Co.
Industrial Heating
Industrial Nucleonics Corp.
Iron Age
Iron Lung Ventilator Co.
Island Creek Coal Sales Co.
I-T-E- Circuit Breaker Co.

LIST OF EXHIBITORS (Continued)

J

Johns-Manville Sales Corp.
Joy Manufacturing Co.

K

Karlson Co., K. E.
Kay Lab.
Kinney Engineers, Inc., S. P.
Koppers Co., Inc.

L

Lake Chemical Co.
Lake Shore Electric Corp.
Larco, Inc.
Leeds & Northrup Co.
Leslie Co.
Linde Air Products Co.
Link-Belt Co.
Loftus Engineering Corp.

M

Magnaflux Corp.
Manco Manufacturing Co.
Manning, Maxwell & Moore, Inc., Shaw-Box Crane & Hoist Division
Mansaver Industries, Inc.
Markal Co.
Mars Engineering and Fabricating Co.
Martindale Electric Co.
Master Builders Co.
Matthews & Co., Jas. H.
McDowell Co., Inc.
Mesta Machine Co.
Mine Safety Appliances Co.
Minneapolis-Honeywell Regulator Co., Industrial Division
Modern Sound Co.
Morgan Construction Co.
Morgan Engineering Co.
Motor Generator Corp.

N

National Carbon Co.
National Electric Coil Co.
Nickel Cadmium Battery Co.
North American Manufacturing Co.

O

Ohio Carbon Co.
Ohio Electric Mfg. Co.
Okonite Co.
Osborn Manufacturing Co.

P

Pangborn Corp.
Pannier Corp.
Parker Appliance Co., Tube & Hose Fitting Division
Poole Foundry & Machine Co.
Porter Co., Inc., H. K., Delta-Star Electric Division
Porter Co., Inc., H. K., Electric Service Manufacturing Division
Porter Co., Inc., H. K., Laclede-Christy Co.
Portomag, Inc.
Post-Glover Electric Co.
Powder Power Tool Co.
Pratt & Whitney Co. Inc.
Pyle-National Co.

R

Radiant Lamp Corp.
Ramtite Co.
Ready-Power Co.
Red Seal Electric Co.
Reintjes Co., Geo. P.
Reliance Electric & Engineering Co.
Republic Flow Meters Co.
Robertson Co., H. H.
Rockbestos Products Corporation
Rollway Bearing Co., Inc.
Rust-Oleum Corp.

S

Scott Paper Co.
Selas Corporation of America
Shell Oil Co.
Simmons Machine Tool Corp.
Simonds Abrasive Co.
Simplex Wire & Cable Co.
Sinclair-Collins Valve Co.
SKF Industries, Inc.
Socony Mobil Oil Co., Inc.
Solvent Service, Inc.
Spraying Systems Co.
Square D Co.
Stanat Manufacturing Co., Inc.
Steel, Penton Publishing Co.
Stephens-Adamson Mfg. Co.
Sun Oil Co.
Sutton Engineering Co.

T

Tennant Co., G. H.
Texas Co.
Timken Roller Bearing Co.
Tool Steel Gear and Pinion Co.
Torrington Co., Bantam Bearings Division
Trabon Engineering Corp.
Treadwell Construction Co.

U

Union Carbide and Carbon Corp.
United Food Management Services, Inc.

V

Valvair Corp.

W

Wachs Co., E. H.
Wagner Electric Corp.
Waldron Corp., John
Westinghouse Electric Corp.
Wheelabrator Corp.
Wilson Engineering Co., Lee
Wing Manufacturing Co., L. J.

Y

Yale & Towne Manufacturing Co.
York-Gillespie Manufacturing Co.

Completion of a new pipe mill, capable of manufacturing 40-in. high-strength line pipe at Consolidated Western's Pipe Mill, Utah, plant and the moving to this location of a smaller mill which manufactures pipe up to 12¾-in., centers production of pipe fabricating facilities near Geneva plate mill.

PIPE MILL, UTAH

By
MAURICE P. KLICK
Chief Engineer
Consolidated Western Steel Division
United States Steel Corp.
Los Angeles, Calif.

▲ IT was just last month that a new pipe mill was completed near Provo, Utah. One railroad spur serving this plant has been given the simple but appropriate name of Pipe Mill. This new addition to Utah's heavy industry is a facility that produces a product which we helped to pioneer in the West.

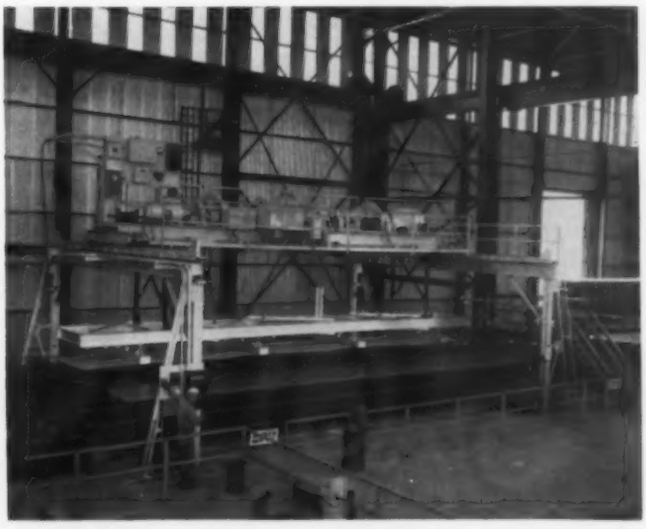
It seemed to us very fitting that we broke ground for this new pipe mill just 100 years after our earliest California predecessor opened a shop in which would be manufactured the first sheet iron pipe for the then new hydraulic gold mining industry in the Mother Lode Country. This early-day pipe manufacturing in the town of North San Juan in Nevada County required importing sheet iron from England, which was shipped around the Horn. It had to be transported perhaps 15,000 miles. For the new pipe mill in Utah the plate and strip are transported about 1,500 ft from the mill of Columbia-Geneva Steel, a sister division of U. S. Steel. The steel is made from iron ore, coal and limestone produced in Utah.

The early-day pipe was riveted and often joined by pushing together like stove pipe. Sometimes it was sold unriveted, cut to size, punched for rivet holes, rolled into a curved shape, and then perhaps a dozen lengths nested together for shipping further into the mountains by muleback. The riveting was then done at the job site.

Hydraulic mining was big business in those days. It is claimed that more earth was moved by the early-day hydraulic mining in California than was moved in dig-

Figure 1 — This scenic shot not only shows the general location of the plant but helps to understand the problem of constructing it during a very severe winter in order to meet some contract schedules.

Figure 2 — The first piece of equipment in the large diameter mill is a magnetic crane device which picks up the plates one at a time from the stack and places them on a conveyor leading to the planers as required.



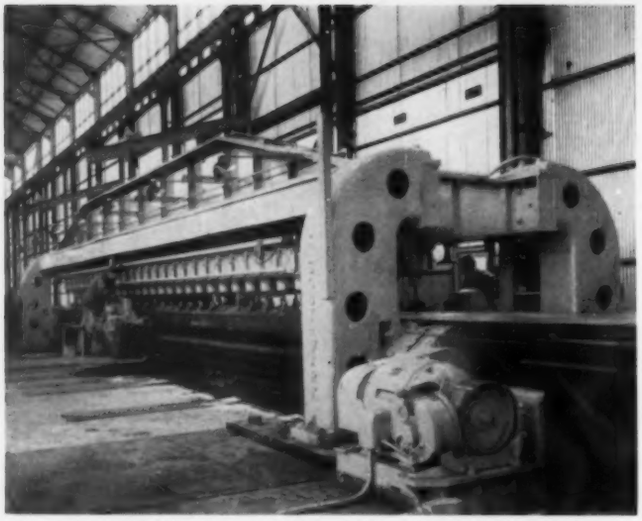


Figure 3 — Both edges of the plate are planed simultaneously by these two operators as the carriages move from one end to the other. Twenty-four cutting tools are mounted so that six cuts are made on each edge simultaneously. One round trip of each carriage is generally sufficient to plane the plate to the correct width and edge finish.

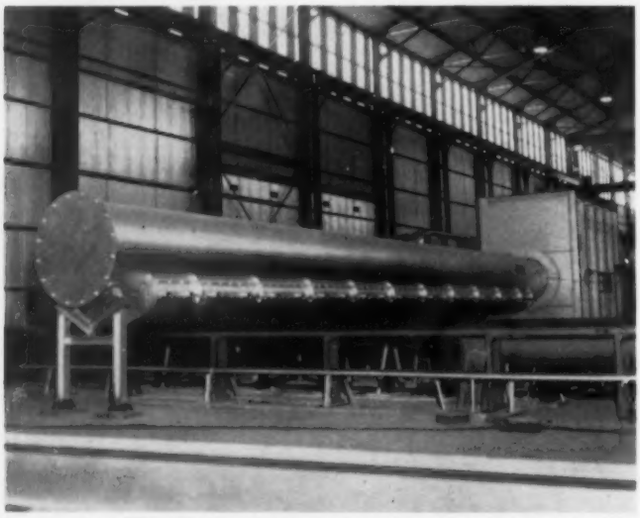
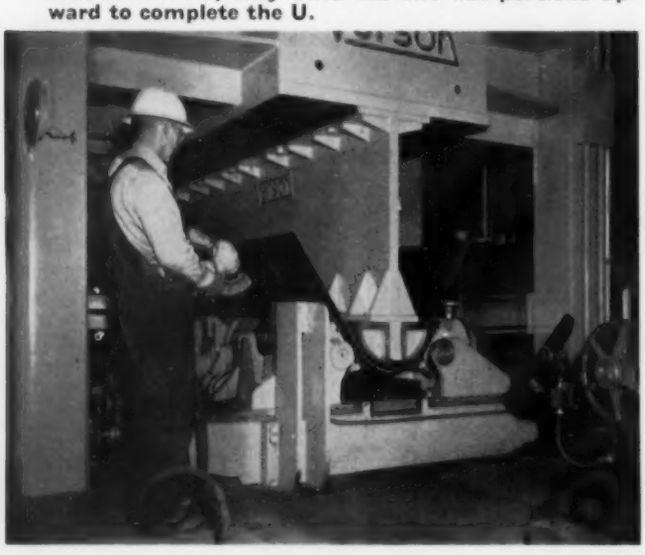


Figure 4 — The plate passes under a heater unit that forces hot air over the plate to dry off any moisture.

Figure 5 — The plate is next placed in a U-ing press. The upper die can be pushed downward with a maximum pressure of 2000 tons. The lower dies consists of two sets of rockers which form the plate around the upper die. After the rockers have formed a curved section around the die, they bend the two flat portions upward to complete the U.



ging the Panama Canal. This required many tons of water for every ton of dirt that was moved. The water was transported to high above the mines by systems of canals, and dropped down to the open nozzles through such thin wall pipe. The hydraulic miners' thin wall pipe soon proved itself very adaptable to another field. Western agriculture needed pipe for transporting waters for irrigation. Pipe made from thin flat-rolled steel products—the type we pioneered in the West—proved to be a very practical answer.

An interesting part of the background to the story of the new mill, is that about 1930 we began to experiment seriously with the relatively new welding process now called submerged arc. We tried a wide variety of materials to keep the air away from the arc. One of the more successful ones was a powder made by pounding up glass telephone pole insulators. Curiously, green glass insulators made the best flux. Later we sent a man throughout the West searching for a certain type of clay. The best deposit proved to be only twenty miles away from the plant where we were experimenting. About that time a commercial flux was made available by one of the big suppliers of today. In a published article of theirs we are given credit for being the first to apply this to production use and it was for making welded plate pipe.

About a decade later, toward the end of World War II, we were searching for postwar products. The mushrooming growth of California's population, its remoteness from coal, and the fact the State's production of natural gas was not keeping pace, resulted in the Los Angeles area gas companies looking to the increasing gas production in Texas that was then being flared into the sky.

Studies indicated a demand existed in the West for a larger diameter line pipe than could then be made by any existing mills. However, such big lines required using every pound of steel efficiently; that is, such line pipe must have a high carrying capacity per pound of steel.

By combining our experience with thin wall pipe and with submerged arc welding, our knowledge of the welding speed advantage of twin electric arcs, plus the al-

Figure 6 — The next press is capable of exerting a maximum force of 16,000 tons to convert the U to an O. In this picture the U-shaped plate is being moved from one press to the next.

ready recognized advantages of physical expansion of the pipe to increase its yield strength and accurately size it, we began to develop a product with great promise.

The gas companies were aware of the fact that sizes of pipe larger than any then manufactured offered two advantages for transporting such large quantities such long distances. First, pumping costs could be materially reduced. Their line was to pass through a desert country where pumping plants were costly to install and operate. Second, a larger pipe for the portion of the line in California could act as a storage reservoir, which is highly desirable at the end of a 1000-mile supply line.

It was still largely a theory that we had been discussing with the Southern California and the Southern Counties Gas Companies, when in 1946 they asked if we would tackle the job of making 210 miles of 30-in. high strength pipe. This was four inches larger than any yet manufactured and six inches larger than the famous "big inch" line made of 24-in. seamless pipe.

About this time, luck entered the picture rather strongly. Over in the Middle East enormous oil wells were being developed and new larger pipe lines were needed to eliminate the 7000-mile journey by ship around the Arabian Peninsula and through the Suez Canal of the Mediterranean Sea. Also, about this time big new gas discoveries were being made in Texas, when public pressure for conservation was becoming adamant. These factors, together with recent rises in prices for competitive coal and oil in the East and Middle West, were creating a demand for bigger and stronger pipe for new long pipe lines from source to market. Finally, this was all at a time, 1946 and 1947, when demand for steel in the East was more than the supply. Yet in the West there were two big steel plants built for wartime shipbuilding and there was no more shipbuilding and no comparable outlet for their plate.

The opportunity was there—far greater than we at first realized. But the beginning was full of headaches and risks. To use the plate capacity to fill the new market demand for line pipe made from plate, we had to make commitments that were very heavy in relation to our division's activities. One western steel mill was unable to quote at first on the required type of plate; the other mill had considerable starting difficulties in meeting the specifications. We were building a product to carry enormous quantities of inflammable fuel at high pressures, so manufacturing tolerances were very rigid. We had a tough battle to bring our costs down to the level that made our big contract commitments profitable.

Figure 7 — As O-ing press dies close, the plate begins to take on a cylindrical form, and is finally converted to a cylinder, or can, ready for welding.

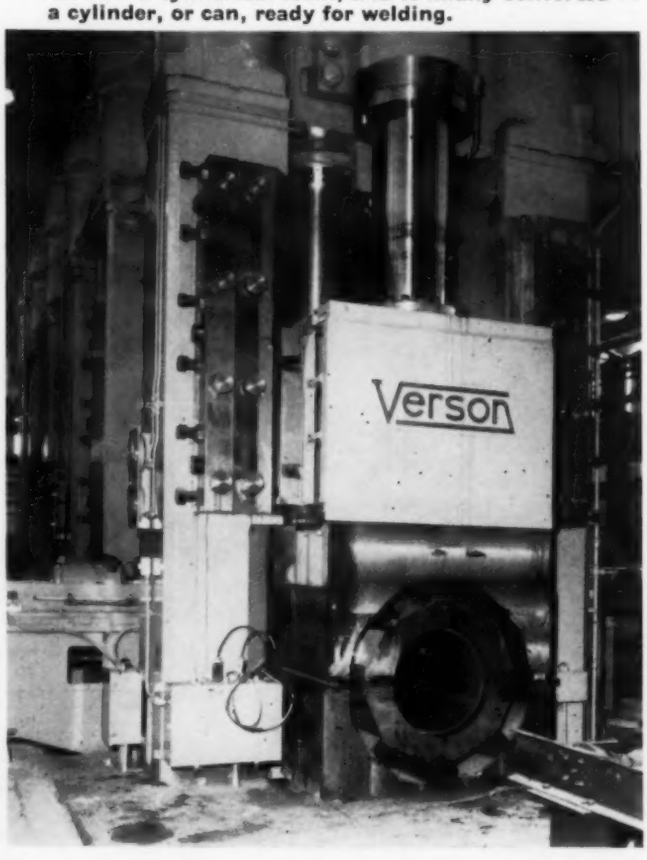


Figure 8 — In order to provide a spot beyond the can for starting and stopping the automatic weld, tabs are attached. With the edges of the can held tightly together, a small plate or tab is welded on each end. After the longitudinal seam welds are completed the tabs will be cut off.

Figure 9 — In this mill, the sequence of welding has been reversed and this has materially improved the quality of the welds. The can is held stationary while hydraulic pressure squeezes these bands. Up to 500 tons of pressure are available to force the edges together while the weld is being made.

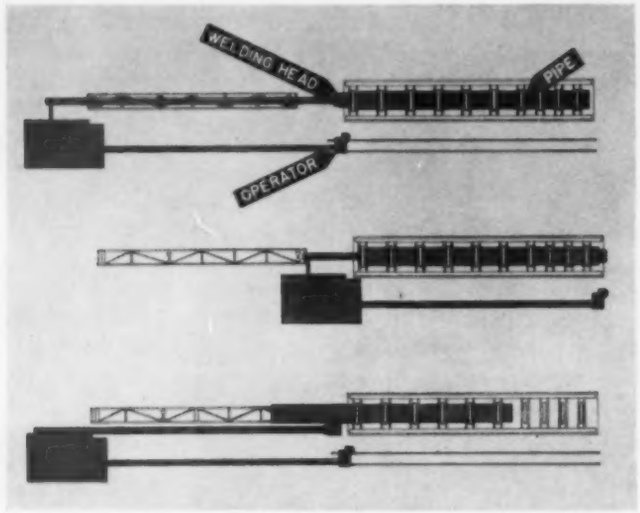


Figure 10 — This drawing helps to show the different positions of the welding unit. In the upper one, the welding head has been alined with the inside of the pipe. One arrow shows the position of the operator. He and his controls travel down the track at the same time the welding head is moving to the far end inside the pipe. The weld is started from this far end and the operator has to be there to see that it starts correctly. The middle drawing shows the position of the units at that time. At the completion of the weld, the units are back into the position of the upper drawing. The lower drawing shows the welding boom retracted out of the way while a conveyor is raised and the pipe is moved to the left to its next position in the production line.

The availability of new large diameters of high strength line pipe was undoubtedly a factor in the economy that has led to the big expansion of long-distance gas transmission throughout the nation since 1946. Consolidated Western is very proud of its claim to manufacturing the first 30-in., 31-in., 32-in., 34-in., and recently 36-in. Its new mill is capable of manufacturing 40-in. high strength line pipe.

From the very beginning we realized that the proper location for a mill making pipe from western plate was close to the plate mill. However, the original job had to be undertaken where we had a large building and some equipment and personnel available. The subsequent demand was so heavy we had little alternative at first except to expand and supplement existing facilities. So this new mill in Utah is the culmination of a plan which we have worked on for nearly six years.

The pipe mill, which Consolidated Western Steel Division of United States Steel recently built and put into operation in Utah, produces two types of electric-weld line pipe for western markets. One production line is for resistance-weld pipe in diameters from 4 to 12¾ in. in lighter wall thicknesses. The other is for submerged arc welded, hydraulically expanded, high strength line pipe, in diameters from 20 to 40 in. and wall thicknesses up to ⅝ in. This requires plate up to 125 in. wide.

This is the sixth such large diameter high strength pipe mill designed and built by Consolidated Western. A large percentage of today's long-distance transmission of gas, if figured in Btu-miles, is carried in pipe made from those six mills using the process pioneered by Consolidated Western ten years ago.

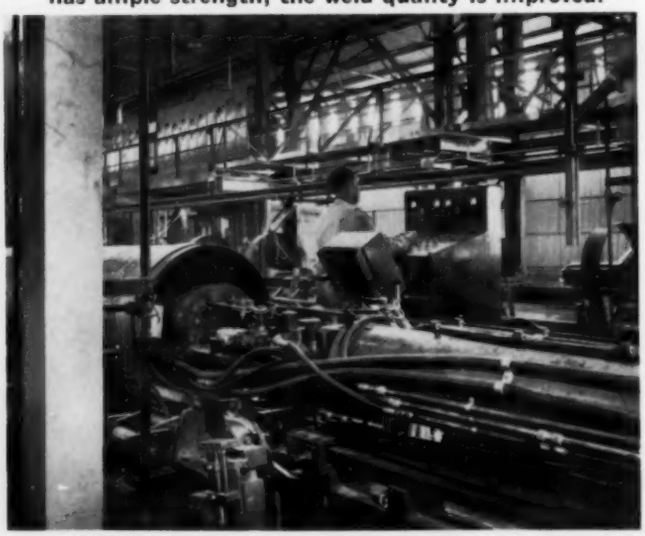
The basic process is the same:

1. Use plate with its relatively close thickness tolerance.
2. Form it into a cylinder or "can."
3. Hold the edges together securely while welding a lengthwise seam with submerged twin arcs.
4. Make a second pass so one weld is outside and one is inside.
5. Hydraulically expand, "blow up," or stretch the pipe against an outside die, to get straightness, roundness, accurate diameter, and to materially increase the yield strength.
6. Test in the expander with the dies open.
7. Machine the ends.
8. Finally, inspect.

At the receiving end of the plant, the automatic plate unstacker for the large diameter mill is operated by one of the two planer operators. One man operates both the U-ing press and the O-ing press. Therefore, only three men are required to carry on the operation of picking up a plate, planing and scarfing each edge, and forming the plate into a round can. Preforming the edges by the use of a machine is entirely eliminated. This saves one operator and one expensive machine.

Figure 11 — The operator is on his moving platform with all the control equipment just beyond the pipe he is welding. The weld is already started and the welding head is disappearing inside the pipe.

Figure 12 — The operator and welding head is shown as the weld is being completed. An important new feature does not show. A blower is used to cool this pipe, particularly at the ends of the weld. By holding the pipe until the weld reaches the temperature where it has ample strength, the weld quality is improved.



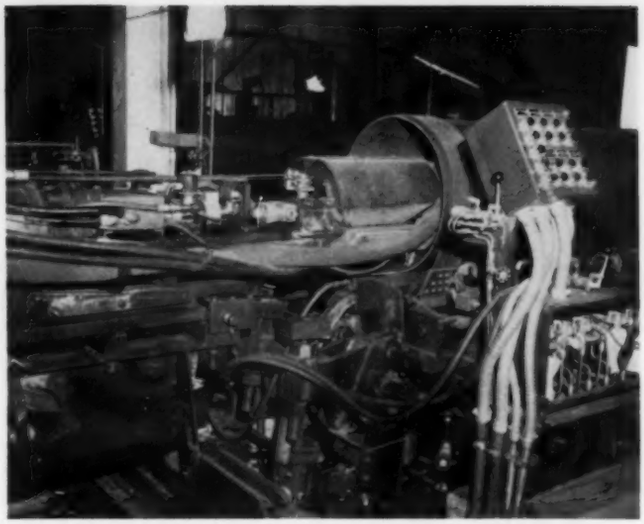


Figure 13 — This view of the welding head from the operator's side gives a better idea of all the mechanisms involved. At the upper right can be seen the control for alining the pipe and welding head. At the left center can be seen a cam which will lift the welding head as it is drawn out of the pipe. All of the equipment shown at the left of the picture moves out of the way as the pipe is moved past to the left.

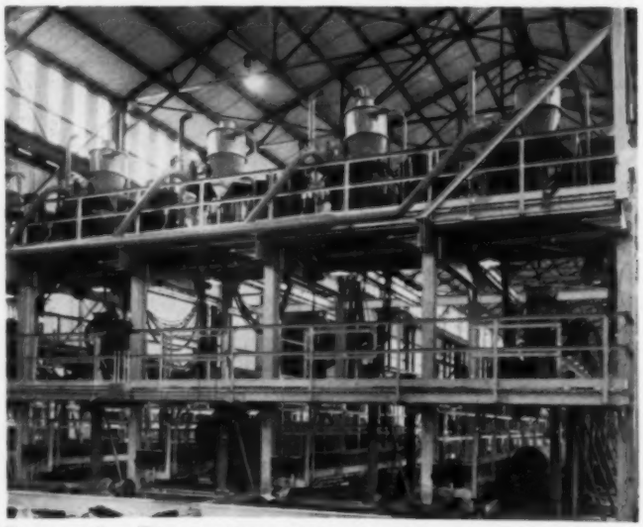
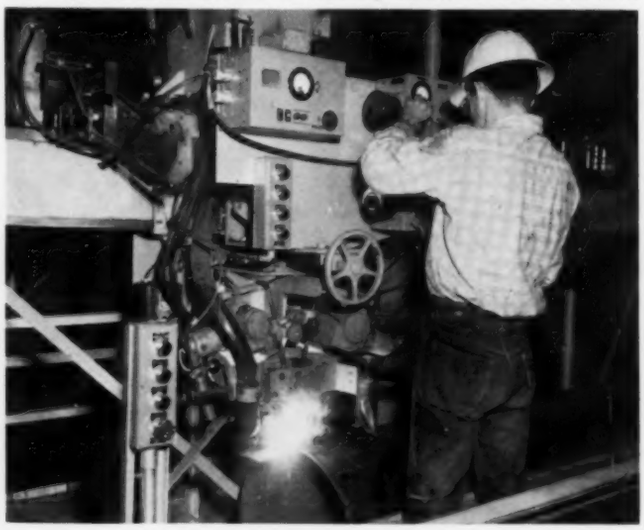


Figure 14 — The section of pipe is now conveyed to one of the five outside welders. The pipe is again held securely while traveling welding machines move on tracks.

Figure 15 — The outside weld is being started on the tab, and the electrodes are feeding down to the twin arc.



Next, the can is placed in a special fixture to hold it securely while the pads for starting and run-off are tack welded preparatory to welding the longitudinal seam. A sigma type (gas shielded) weld is used as it gives a better base to weld over with a submerged arc longitudinal seam weld and eliminates porosity which might occur if any welding flux from automatic tack welding were left in place. We therefore have, up to the point of making the longitudinal seam, a two-step forming and a tacking of the end tabs.

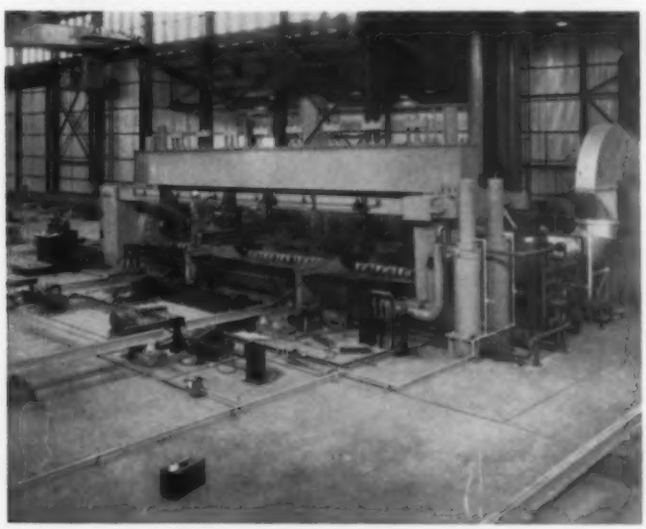
Of major importance is the reversal of sequence of welding of the longitudinal seam by doing the inside weld first. By a series of hydraulically operated bands, using up to 2000 psi, the can is securely held in place with a maximum of 500 tons of pressure available to hold the two edges together. Now, with the pipe held stationary, the ends of the pipe are cooled after being welded by blowing air on them until the strength of the weld material is sufficient to hold the edges together before the pipe is unclamped. This new equipment and change of weld sequence results in an improved weld.

The rather unique boom welding units are of interest. The man operating the moving automatic welder rides right along side the welding operation. When the weld is completed, the welders fold out of the way so that the pipe may move past to its next station. There are five of these automatic inside welders, as well as five somewhat similiar traveling outside welders.

The hydraulic expander in the new mill has several major improvements. One is the tilting of the whole expander to twice the former angle so that the water would flow into and out of the pipe section more rapidly. Another improvement is the use of an intensifier to boost expansion pressure up from 3000 to 5000 psi to handle heavier wall thicknesses of such high strength pipe. Cast dies are used which weigh 11 tons per section. Hydraulic shock absorbers cushion the opening and closing action of the outside dies.

The design of the ram and the stanchion on one end of the expander involves some interesting new features. While it is designed for 40-ft lengths, it is capable of expanding lengths as short as 35 ft.

Figure 16 — The final major operation is the hydraulic expansion. A large number of improvements have been made in the expander and related hydraulic system. The equipment has also been heavied up so it can handle larger diameters and heavier wall thicknesses.



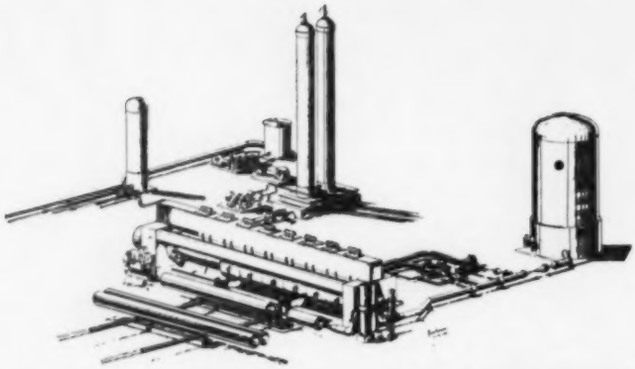


Figure 17 — The various elements of the hydraulic equipment involved are shown on this schematic drawing. At the right is a large fill accumulator tank. It operates at about 100 psi and is used to fill the pipe rapidly with hydraulic fluid. The two tall vessels in the back center are the pressure accumulators. One handles pressures up to 1500 psi and the other 3000 psi. Intensifiers on the right end of the expander itself boost this up to a maximum of 5000 psi when needed for heavy wall pipe. The tall vessel on the left background is the pressure tank to service the ram.

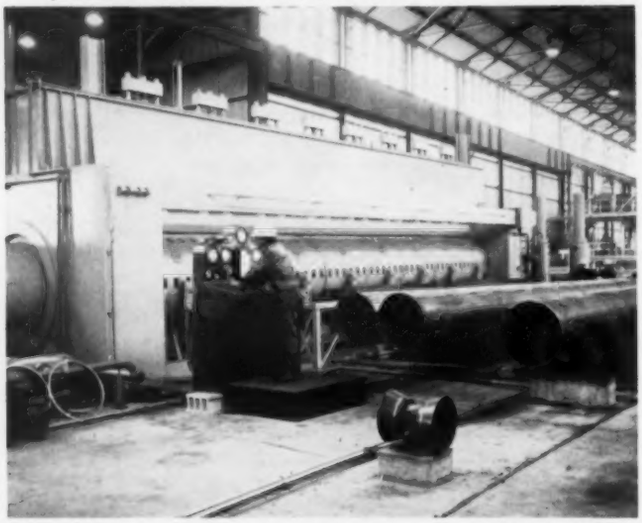


Figure 18 — It is necessary to keep a proper ratio between the pressure inside the pipe for expanding it and the pressure on the ram for following up and maintaining the seal, as the pipe shortens nearly six inches during expansion. The expanding pressure varies with both diameter and wall thickness, and the ram pressure must be further varied for different diameters. An elaborate hydraulic system automatically adjusts the ram pressure.

Figure 19 — Inside inspection of some large diameter pipe can be made by a man on a dolly.

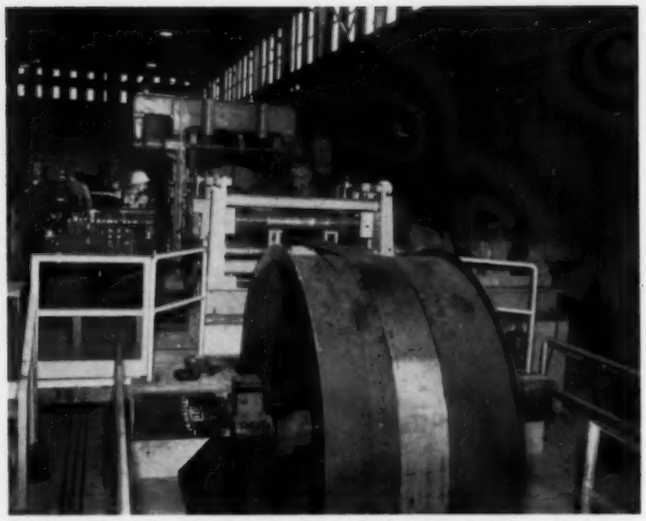


Figure 20 — At the beginning of the production line, on the small diameter mill, the coils are slit to proper width and recoiled. Next are pinch rolls, shears and a welder. In the foreground, the strip for smaller diameter pipe is going around the deflection drum to a new type of looper below the floor.

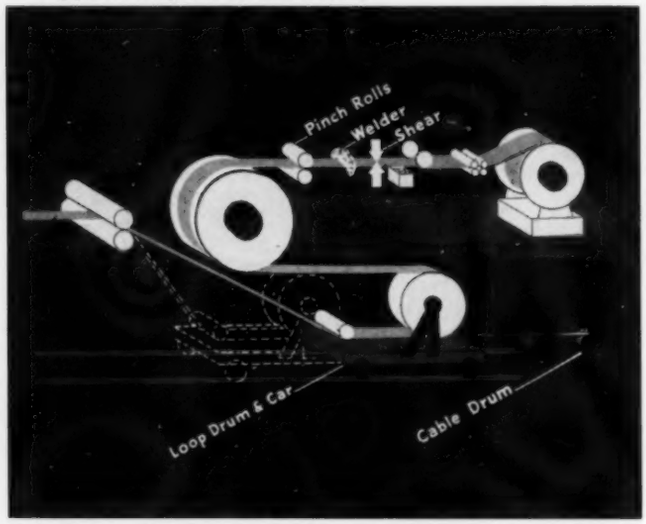


Figure 21 — Because of soil conditions and to conserve space, a unique type of horizontal looping was devised. It is built to handle coils of up to ¼-in. thick and 40-odd in. wide. The pay-off reel is at the right in this drawing. The main controlling pinch rolls are just to the left of the welder before the deflection drum. They stop the trailing end to permit shearing, move it to welder and hold it until the new coil is in place. The new coil is fed to the shear and then to the welder and the weld completed. In the meantime, most of the 160 ft of carriage travel will have been used feeding the forming and welding equipment. The track can be materially extended if necessary. A hoist with an electric clutch mechanism maintains the proper tension on the cable attached to the car.

The ram has to perform a dual function. First, it mechanically bells the ends which would otherwise not expand equally with the rest of the pipe because of friction. Second, it must assist the natural tendency for taking the extra material for the increased circumference from the length of the pipe instead of the wall thickness. The ram has to move in about four inches as the pipe expands about ½ in. in diameter. The relationship of ram pressure to expansion pressure varies with diameter. A new hydraulic system permits rather easy adjustment.

The small diameter mill in the same building is largely made up of a continuous resistance-weld mill we

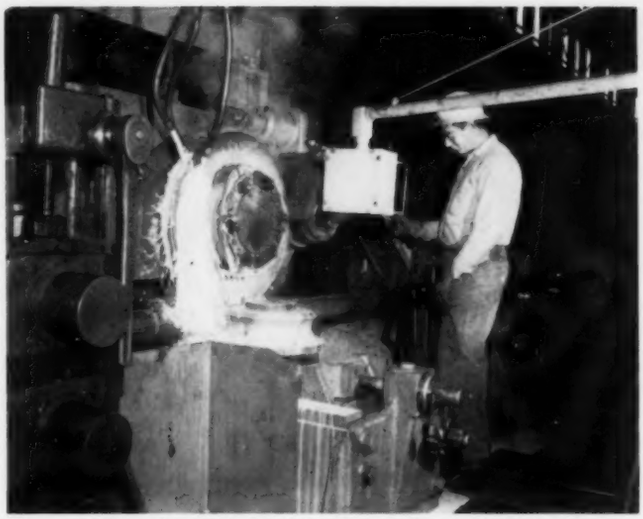


Figure 22 — The pair of wheels on the resistance welder apply very high amperage and low voltage for the resistance weld. At the right, in front of the operator, a tool is trimming off the upset material and coiling it just to the left of the white control box. A similar trimmer on the inside is anchored on a boom secured at a point to the left before the pipe is finally closed.

moved from our Berkeley, Calif., plant. We had much to do with its original design and added a number of other features, but the improvements are largely technical or combinations of steps used elsewhere.

Consolidated Western Steel Division built as well as designed the pipe mill. The long-planned consolidation of U. S. Steel's electric-weld pipe manufacture in the West near the source of its plate and strip production was rushed to completion to supply a new pipe line which passes near this location. One of the West's newest long-distance gas transmission lines will connect the big gas field of northern New Mexico with a line from the Peace River gas field of Canada. This will bring natural gas to the Pacific Northwest and provide the nucleus for a new western network.

To meet the construction schedule of this new transmission line from a mill still to be built required breaking ground October 1, 1954. Construction had to be carried on in winter, and in what turned out to be a very severe winter, at the foot of 12,000-ft Mt. Timpanogas, highest peak of the Wasatch Range of the Rocky Mountains.

Despite encountering quicksands that soil tests failed to disclose; despite having to thaw the ground and protect newly poured concrete foundations and footings under canvas-covered heated structures; despite having to comb the nation for special valves and other scarce pieces of equipment; and, finally, despite having to train all but the nucleus crew and work out the "bugs" in many innovations in the process, pipe from the large diameter mill began to roll out of the plant in the seventh month.

The moving of Consolidated Western's small diameter mill from Berkeley, Calif., to Pipe Mill, Utah, was held off until the large diameter mill was in full production. In January 1956, fifteen months after groundbreaking, both units were completed. By the time of completion of the whole pipe mill, nearly 140,000 tons had already been produced.

We believe this new plant at Pipe Mill, Utah, represents the most advanced practice in the production of both high strength electric-weld pipe in diameters up to 40 in., and in thin wall pipe in diameters from 4 to 12¾ in., and that it is strategically located to best serve the West.

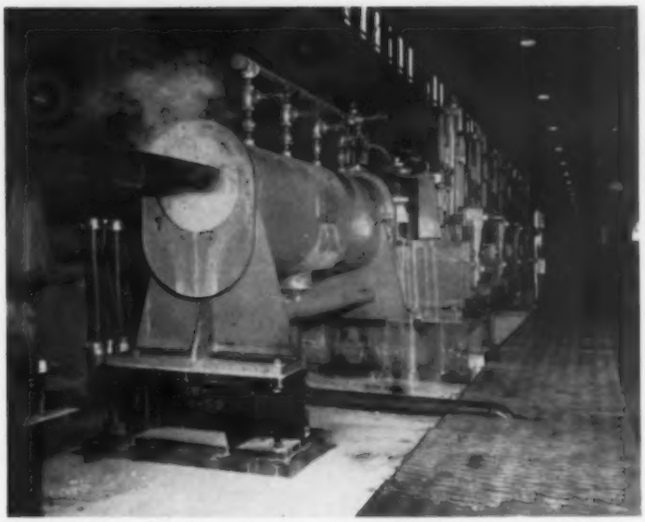


Figure 23 — Cooling of the pipe is followed by straightening.

Figure 24 — The flying cut-off is capable of cutting lengths up to 60 ft. This smaller-diameter pipe is made in diameters from 4 to 12¾ in., averaging 50-ft lengths. For water pipe, 10 and 12-gage sheet coils are used. API line pipe for gas and oil is also made in wall thickness up to 0.188 in.

Figure 25 — This machine can give the pipe a hydrostatic pressure test and inspection.

By R. E. MORTON, Executive Vice President, Morton Manufacturing Co., Muskegon Heights, Mich.

A Practical Approach to *Coil* Splicing

. . . . successful continuous production processes depend on successful splicing of smaller units . . . . welds should be sound and ductile to avoid later breakdowns and time element for welding must be short to maintain line speed and minimize work storage and holding problems . . . .

▲ THE ceaseless demands of steel and non-ferrous industries for a coil joining method suitable for handling a wide range of material types in gages from 0.009 to 0.250 in. thick, have spurred machinery manufacturers to develop new equipment and processes to meet that demand. The further requirement that such machinery be suitable for operation by unskilled labor has lead to a high degree of automation and a resulting application of hydraulic, electrical and mechanical components which must be kept operative by mill maintenance engineers. The application of submerged arc, tungsten inert gas, and metallic inert gas welding to hot and cold rolled mild steels, stainless steels, and silicon steels as well as non-ferrous materials such as copper, bronze, aluminum and magnesium has presented several serious problems requiring extensive research and development.

Steel mill requirements for a weld subjected to cold reducing vary widely for each application. The two coil ends must be held to an average centerline with some form of centering unit until heavy duty clamp bars with sufficient power to flatten the strip have been applied as close to the joint as possible to minimize the effect of coil set. The final welded joint must have little or no reinforcement, but must have full penetration particularly at the two edges. The characteristics of the weld deposit for ductility, tensile strength, and metallurgical properties should match the parent strip while keeping total cycle time for welding to a minimum.

Unskilled labor is utilized to operate the equipment which must be strong enough to withstand accidental abuse from moving strip. Protective rolls are required to shield the product from damage with provision for easy threading of the strip through the machine. Complete safety interlocking of all parts must be incorporated in the design along with quick change selection of a series of welding conditions which have been preset by a technician.

Maintenance of a welding machine requires a comprehensive study to keep operating downtime to a minimum. As far as practical normal service on expendable items such as backup bars or items requiring periodic change, such as shear die sets, should be accomplished with the line in operation. In the case of multiple electrode welding, a selector switch change to single electrode operation for emergency repairs on damaged parts is advisable.

The basic welding requirements of clean steel, weldable material and good fit-up apply whether the product is a water storage vessel, an automobile bumper guard, or strip steel. This means that the material being welded must be free of lamination, heavy scale or rust, grease, oil, concrete dust or any gas producing foreign matter. The joint control must be very precise which requires good square sheared edges with a burr, if any, facing upward. The welding equipment can of course absorb some variation in materials but must be exactly repetitive in its control of voltage, amperage, wire feed rates, and travel speed without the necessity of continual adjustment by an operator.

Three practical machine designs of many which meet the requirements previously discussed are shown in Figure 1.

All three machines illustrated are built from the same basic components with change in physical placement to suit varying conditions. The center unit is a strip transfer equipment where the two coil ends are first securely clamped to a car or carriage which then moves the strip longitudinally from shearing to welding stations. The unit on the left is a machine transfer unit which also clamps the two coil ends. Here, however, the two units of shear and weld trimmer move transversely

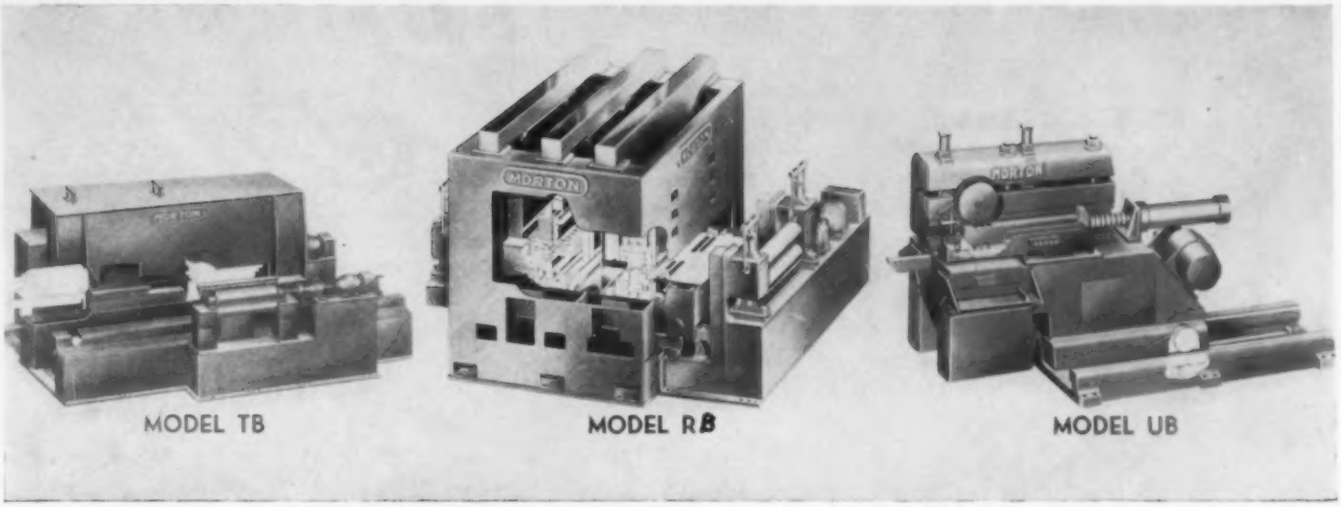


Figure 1 — These three practical machine designs meet the requirements for steel plant coil splicing equipment.

requiring only sufficient strip and clamp movement to close the gap left after square shearing. The unit on the right is for narrow strip and multiple strand application. Its open throat design and traverse base allow shearing and welding on any of several strips in a single line such as might be found in strand annealing lines.

Let us analyze the mechanical components and how they function. Assume that the coil ends have been previously crop sheared to remove fish tails. This cropping should go far enough back from the end to remove pipe and lamination. This can be accomplished at the start of the line or in an earlier line depending upon the mill layout.

Center both entry and exit strips—This is a controversial subject and has endless variations. The conventional approach quite commonly used is shown in Figure 2.

This type of centering selects two edges and by mechanical effort applied to the strip moves it to the average centerline. Mechanical stops or electrical contacts can be applied to limit the power application thus preventing damage to strip edges. This works satisfactorily on heavy strip, 16 gage or over, where the strip has been previously looped to allow for easy side movement. In some cases it has been suggested that two such units placed some distance apart (from 4 to 15 ft) would provide a better average centerline for joining.

One of several mechanical variations which minimize strip edge damage particularly suitable for light gage strip (0.009 to 0.060) is shown in Figure 3.

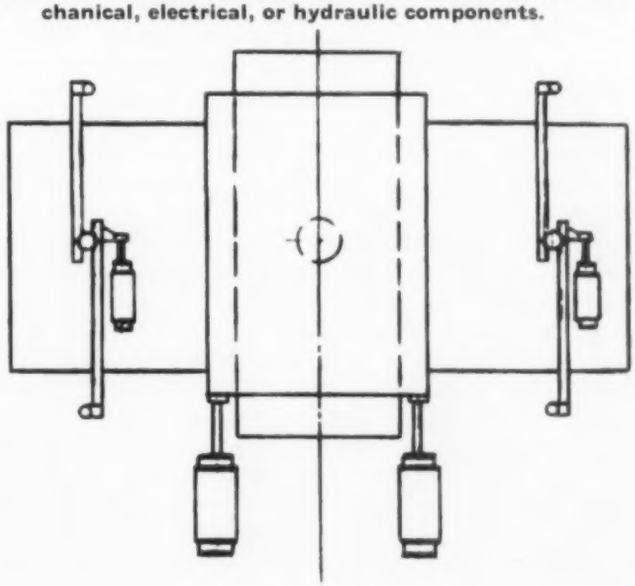
Here a flat circular clamp securely traps the material in whatever location it reaches the welding machine. The entire clamp assembly is then mechanically powered to self-center on the machine centerline by means of a power cylinder signaled through tracing probes. Such a system can be a combination of mechanical, electrical or hydraulic components to accomplish the movement. The important factor is that the strip is moved while clamped flat and not by application of mechanical leverage on its edges. The spacing of the probe devices can be located to best suit a particular shape configuration.

Clamp both edges to be joined—General clamp force requirements vary greatly. The important factor is to have sufficient power to clamp practically flat. Tests on various types and gages of strip indicate that primary clamping of 500 to 800 lb per lineal in. will effectively flatten most strip. The clamps should be as close to the joint as possible to minimize the effect of coil set. It is important that this holding of the material never be released or changed until the welding is complete.

Shear both edges—As with most phases of welding, the edge preparation and square shearing is a subject of considerable discussion. All methods are a compromise and the material to be welded and its thickness have an important bearing on shearing procedures. A good weld needs both edges parallel with any burr or bend produced to be upward. Figure 4 shows two methods of shearing.

Figure 2 — Conventional approach for centering applies mechanical effort to the edges of the strip.

Figure 3 — Tracer probes may be a combination of mechanical, electrical, or hydraulic components.



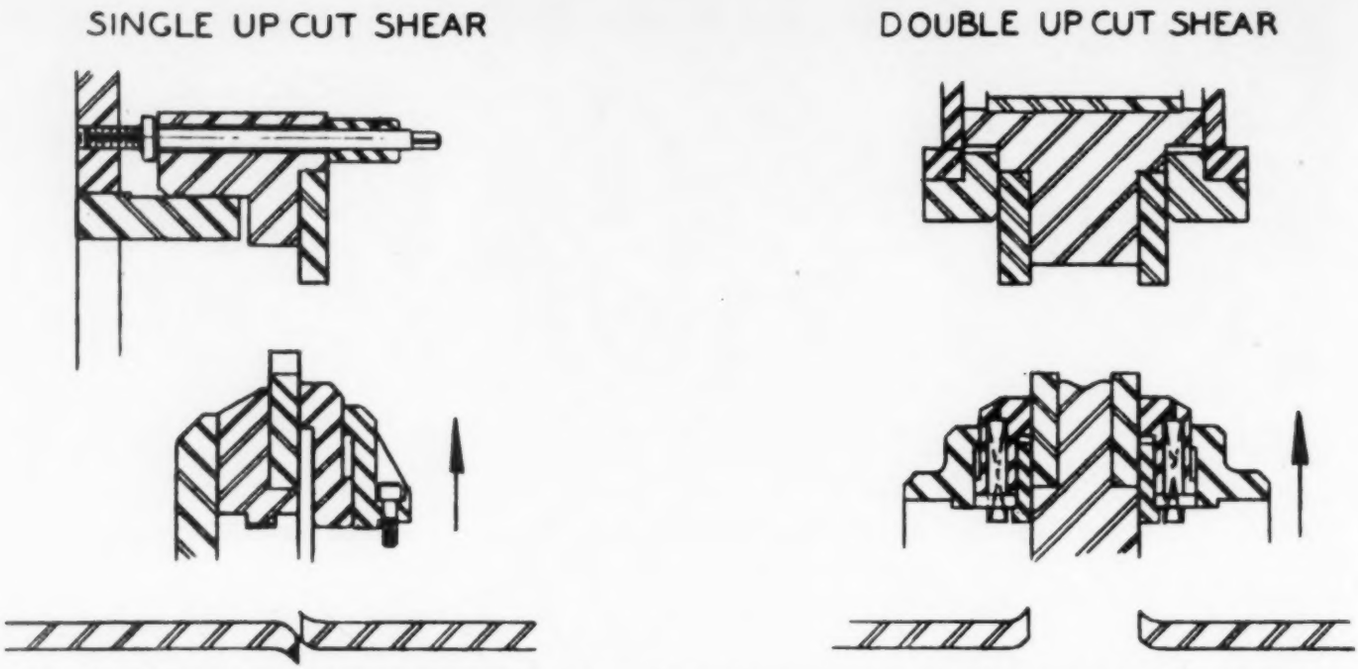


Figure 4 — Two methods of shearing commonly used are the single up cut and the double up cut shear. Note on bottom of figure the difference in appearance of edges.

Any form of single shear which operates on two adjacent coil ends will produce an edge with one edge up and the other down. The selection of upcut or downcut is purely mechanical and has no bearing on the end result.

One method of double shearing with both edges curved upward is illustrated at the right of Figure 4. This type of operation again can be either upcut or downcut. The joint produced will remain the same. On heavy gage strip or brittle materials which shear with little or no burr, the relative importance of this joint structure is somewhat a matter of opinion, however, other factors such as a controlled joint and further processing in the welding machine justify the accurately spaced double blade shear die set. Materials securely clamped in position and cut on a single shear must be subsequently moved to avoid overlapping. If a shear were a machine which accurately parted material without deflection and without blade clearance, two subsequent coil ends cut on the shear would match exactly. A single shear, however, will not produce such a joint, therefore, it seems more advisable to utilize the more complex system of joint shearing and subsequent mechanical push up which, while it requires greater accuracy in setting, can be designed for interchange with the line in operation. Servicing and resetting to original accuracy can be done in a machine shop. It is important to note that variations in shearing place a greater demand for critical control of the welding operation.

Move relative location of strip joint to weld centerline—This move can be accomplished in several different ways. Any system of accurately controlling such movement produced with sound mechanical components is entirely satisfactory. Two basic systems of motion are currently being utilized in the industry: (1) to move the strip or machine longitudinally, and (2) to move the machine transversely. The selection of basic motions depends to a great extent on the layout of an individual line. Generally speaking, a longitudinal movement requires less floor area but is inherently more costly to produce, as more machinery parts must move to clearance positions away from clamp jaws and accessory equipment. Floor space and equipment cost must be jointly considered and the best compromise selected. The final weld result is in no way affected by the method of transfer. Final choice depends on the overall machine design, therefore, no clear cut decision on one best combination can be made.

The selection of a suitable welding or weld-trimmer unit to accomplish the joining of two coil ends depends upon several factors: (1) selection of a suitable welding process, (2) time cycle allowable to determine number of weld heads to apply, (3) selection of necessary mechanical equipment to apply the welding process selected, (4) determination of necessity for surplus metal removal by trimming or other means, (5) frequency of replacement of expendable items and their accessibility, and (6) automation required to make the process operable by unskilled labor.

1. *Selection of welding process*—Three basic welding processes are employed in coil splicers of this type. The first is tungsten inert gas with or without wire feed. It uses a nonconsumable tungsten electrode gas shielded as a heat medium. It is used for light gage materials in a range of 0.005 to 0.080 in. thick. The process can be extended to cover up to 0.250 in. thick, however, speed of operation and joint preparation requirements make other processes more suitable. This process is particularly suited to the welding of nonferrous materials, stainless steels, silicon steels, and killed low carbon mild steel cold rolled or pickled. It is well to note that hot rolled mill scale makes a very porous weld. Extensive development welding throughout the country indicates that special wires fed into the arc will help to scavenge and clean the weld joint. To date, however, the process applied to hot rolled mild steel has been only mildly successful with the use of

stainless or bronze wire which produces a mechanical bond or braze and leaves some metal reinforcement at the joint. The second process, metallic inert gas, is a relatively new process where a consumable electrode is fed into the work, gas shielded. It is particularly adaptable to heavy gage strip from 0.080 to 0.250 in. thick. This process is suitable for welding non-ferrous materials, stainless steels, silicon steels, and hot rolled low carbon mild steel. The third method, submerged arc, is a well established process where a consumable electrode is fed into a powdered or granular flux material. This flux when heated forms a gas and a glass like coating over the weld. Its primary application is on heavy gage strip from 0.080 to 0.250 in. It is applied to hot rolled mild steel, some stainless steels, and some silicon steels. This process requires the depositing and subsequent pickup of the granular flux material. Machinery designed to apply the process must have considerable protection against the abrasive action of fine particles of this material. For this reason, plus the problems encountered in vacuum pickup of the flux, it is not being applied extensively on new coil joining equipments.

A complete discussion of all the good and bad features of the various welding processes together with all the power sources commercially available cannot be covered in this paper.

Selection of a time cycle—Naturally any downtime to accomplish a weld means loss of tonnage in a given line. It would be ideal to make an instantaneous joint without stopping. However, such a process is not presently available; so to compensate for such time loss, the entry section of a given line is run faster than the exit section. The surplus strip is stored in some form of accumulator facility which generally determines the time cycle allowable. Storage of strip is an expensive and space consuming problem, so the natural evolution has been to consider multiple welding heads as a time reducing means. Here again the complete problem of welding variations such as starting, stopping and overlapping of welds has required considerable research. For purpose of this paper we shall limit our statements to say and verify that, with proper application mechanically and electrically, multiple head welds on a given strip are successful.

Selection of mechanical equipment—Two distinct styles or types of equipment are required, one for light gage and one for heavy gage. No rigid rules can be laid down in selecting a design since a welding process and the final weld results required lead to a compromise for a particular line. Generally speaking, however, light gage strip from 0.005 to 0.080 inches falls in one classification and 0.060 to 0.250 in. makes a second. It is mechanically sound to modify a heavy gage machine to weld the light gage ranges, but the reverse attempt to use equipment designed for light gages beyond normal ranges is a definite compromise which sacrifices considerably in time cycle, weld control, and acceptability of the welded joint for further processing.

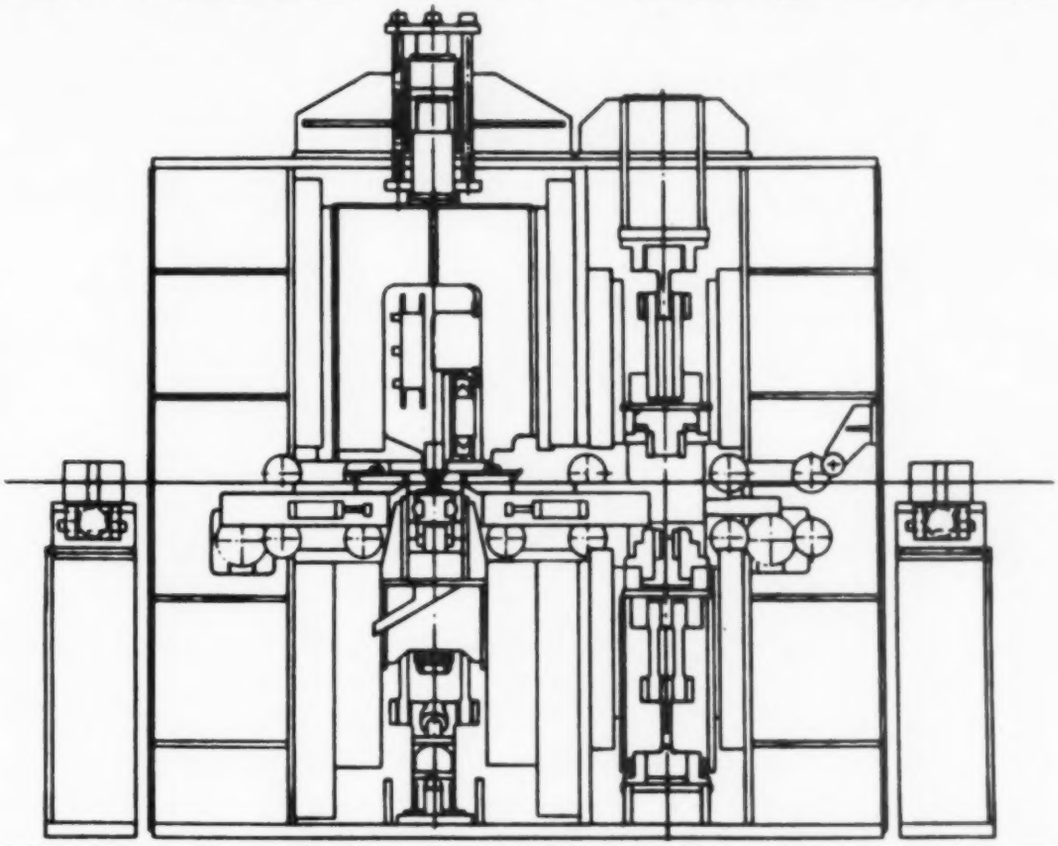


Figure 5 — In this machine, strip is transferred longitudinally from the shear section to the weld or weld-trim section.

The following will describe a heavy gage machine and show the modifications to adapt for light gage welding. Several design factors must be incorporated to provide consistently sound welds. Referring to Figure 5, accurate alinement of the joint to be welded with the path of welding travel is essential. The gap left by the upcut shear die set must be closed to a predetermined point and the final joint must then be located on the centerline of weld head travel. Several suitable methods are available. The specific design selected for this discussion utilizes heavy duty adjust-

able stops which locate the sheared edge of the strip in both shear and weld stations. The push up of the carriage jaws, hydraulically or mechanically actuated, also has adjustable stops. If the primary clamping force is sufficient to flatten the strip the subsequent use of these jaws to move and position the strip is mechanically sound. Taper locating pins or similar locking forms were abandoned, as means for wear adjustment and initial alinement proved to be both difficult and costly.

Secondary clamping of the joint is essential. It must have sufficient power to flatten the strip but retain flexibility enough to conform to thickness variation or shape inherent in two strips. Power application must be in close proximity to the welded joint.

Tests to determine power requirements have not covered the full range of materials and shapes being produced today. Tentative results to date have indicated a secondary clamping force of 1000 lb per lineal in. in conjunction with a primary clamping force of 500 lb per lineal inch does a satisfactory job. These figures apply only where the primary and secondary clamps are very close.

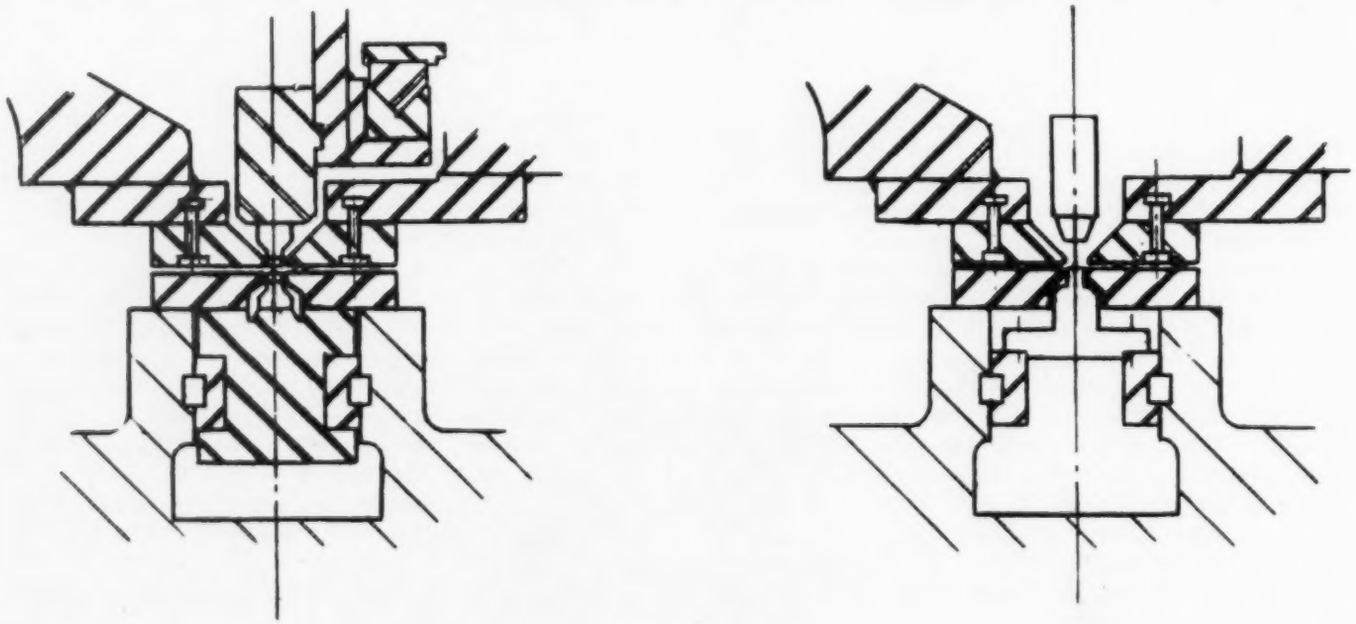
The most commonly used back up material is some form of copper. Its three main functions in the welding process are to provide underbead shape control, shielding of the molten pool from the atmosphere, and cooling of the completed weld. It must neither adhere to nor contaminate the welded joint, but must be able to withstand high temperatures. In the case of traveling bars that are required where trimming occurs simultaneously with welding, the bar is also subjected to considerable abrasion. In any case the backup is an expendable item and is so applied as to be replaced quickly without stopping the line.

One of the most important factors affecting a weld is the speed of travel. The mechanical elements used to accomplish this travel must be powerful and well regulated. Electrical and hydraulic drives have both been applied successfully. Each type has limitations and both require good control. One important feature to consider in selecting a drive is the ease of preselecting a series of repetitive speeds. The design shown in Figure 5 utilizes a hydraulic piston motor controlled by pressure compensated meter-in flow controls. This particular unit provides good speed regulation with sufficient power to trim a weld joint during a welding cycle. Remote selection of different speeds in a series of preset panels is accomplished with conventional valving electrically controlled.

It goes without saying that the weld heads must remain in a set path after having been positioned. They require a series of joints to properly position them over the weld area, and are designed to be readily accessible but rigid. Most commercially available torch mountings are of a universal nature designed for wide range application and hence are not rigid enough to withstand the shock inherent in a strip mill.

One of the more important requirements in producing consistent weld results is full penetration close to the first point of two edge match. This has been accomplished in the past by setting limit switches to graduations indicating strip width. This, however, means an operator change for each width change. One scanning method for locating the two edges has been incorporated in the design. Two precision limit switches set to ride on each side of the weld centerline are placed a fixed distance ahead of the welding torch. As the machine travels along the seam, one limit switch contacts the widest strip edge. The second limit switch is still open and remains so until the narrower strip edge is contacted. When both switches are closed they actuate a distance measuring device which is set to the spacing between the switches and the welding head. After measuring the exact distance desired, the welding current is applied and the weld starts. Starting at the extreme edge may cause a burn out, or spoil a backup bar, so normal practice is to start the weld approximately ⅛ in. beyond the point of match. The same basic scheme of measuring is applied for determining the weld shut off point. This scheme adds to the control complexity and does require care in set up to

Figure 6 — Sketches illustrate differences between the heavy and light gage trimming. Heavy gage trimmer is on the left.



maintain accuracy, but the distinct advantage of removing a set up function from an operator, plus more accurate placement of weld starts and stops, means a better and more consistent weld on both edges.

The addition of a series of control devices which can be set by a welding technician to cover varying types and thicknesses of material is a real advantage to a steel mill. A multi-position selector switch used by the operator automatically sets up the proper welding process for any given material. This control scheme makes it possible to run a wide range of materials through a line intermixed in any order while utilizing unskilled labor with no knowledge of the required process. Each panel applied to the machine controls each of a multiple number of welding heads and establishes voltage, amperage, travel speed and wire speed. The control devices must be carefully selected to repeat exactly. Suitable compensation for line voltage fluctuation, operating temperatures, and all other variables are required to make the system consistent. This means that an operator following a schedule of mill orders need only refer to a chart which tells him which panel to use and a sound weld will result.

Another factor to be considered in the design of coil splicing equipment is two way protection between the strip and the machine. The conventional approach is the application of a series of protective rolls which are moved into position above and below the pass line when the machine has completed its cycle and strip is running through at line speeds. The resulting compromise between throat opening of the machine and the number of protective rolls must be determined for specific applications.

All welds are a compromise to best suit the ultimate requirements of further processing. One major question which arises is, can a weld be produced consistently without build up in heavy strip? The author's experience to date, indicates that a sound weld can best be made in heavy strip covering a fair range of variables of material, joint preparation and weld process control when a surplus of material is applied at the joint. This surplus deposit is subsequently removed by trimming. Research to date on accurate control of the weld leaves much to be desired, therefore, it seems advisable to incorporate some means of bead removal rather than impose added restrictions on all weld requirements or on the further processing of such welds. As progress is made in our development of welded joints, this requirement may disappear. The joint effort of industry as a whole is to make such a process possible.

One method of surplus bead removal is incorporated in the design shown in Figure 5. A series of tools preset in elevation remove the bead during the cross travel of the welding torches. This particular combination of mechanical components does eliminate the necessity of moving and relocating the weld joint to perform the removal of surplus metal deposited. A distinct time advantage results which means less storage of strip is required. The removal and replacement of the cutting tools without stopping the line has been carefully worked out during the past fifteen or twenty years and requires no explanation at this time.

Figure 6 shows one practical changeover system to adapt the machine under discussion to light gage work. The tool block assemblies are removed in the same manner as a normal tool change. A rigid backup bar is placed in the lower housing and locked in position. Two upper holddown clamps are cam locked to the upper housing and are spaced approximately $\frac{5}{16}$ in. apart. The multiple welding torches are of special design to permit a rapid changeover from metallic inert gas or submerged arc to tungsten inert gas welding. Electrical switchgear remotely actuated, accomplishes the welding power supply changeover (if required) and the machine is now ready for light gage welds.

The time element for such a change depends to a great extent on the handling facilities available. It is the consensus of opinion of design engineers and operating personnel that this change can be accomplished in less than 30 minutes. Actual operation in a mill over a long period of time will undoubtedly improve the design. The important factor of this or any other design is to first have available all the mechanical features required for consistently good welds, and secondly to accomplish any required change in a minimum time. A compromise on good welding conditions is far more serious and costly than a little added time to accomplish the conversion.

One of the greatest challenges from a design standpoint lies in producing a machine with the aforementioned features, which can still be maintained with strip material traversing through the machine. The changeover time to replace such units as shear die sets, backup bars, clamps or welding torches should not exceed the length of time it takes to run one coil at line speed into a storage facility such as a looping pit or accumulator. Such service should be accomplished without line shutdown.

The high degree of automation incorporated in coil splicing machinery necessarily requires closer tolerances in manufactured parts, and a higher degree of inspection to make parts completely interchangeable without hand fitting. This also places greater demands on steel mill engineering and maintenance groups to still further improve technical skill and knowledge of hydraulic, electrical and mechanical equipment.

DISCUSSION

PRESENTED BY

H. N. SCHUMACHER, Superintendent, Cold Strip Department, Inland Steel Co., Indiana Harbor Works, East Chicago, Ind.

R. E. MORTON, Executive Vice President, Morton Manufacturing Co., Muskegon Heights, Mich.

ANTHONY TOHIR, Design Engineer, Irvin Works, U. S. Steel Corp., Dravosburg, Pa.

M. D. BAUGHMAN, JR., Assistant Chief Engineer, Wean Engineering Corp., Warren, Ohio.

H. N. Schumacher: What the operating man is actually interested in, in continuous pickle lines and in cold reducing mills, is more production. The way to get more production is by making bigger and bigger coils. These larger coils must be spliced or welded. In splicing or welding we have to have two important factors: first, we need a weld that will hold up as it is being cold reduced in high-speed mills traveling from

3,000 to 6,000 fpm, and under reductions from 35 to 90 per cent. Second, we need a weld that can be made in a minimum of time. Any time spent in making a weld or splicing coils in a pickling line costs pickling tonnage.

The principal part of the problem, as an operating man views it, is this: the human element, the man who makes a mistake in making a weld, by not squaring his ends properly, by not centering his strip, by not directing his voltage correctly for the gage and the material, should be eliminated. The development and research that Mr. Morton has made and presented to us this afternoon has in effect once more brought to the industry an opportunity to become automatic, to take away the human failure element.

Therefore, I would like to ask two questions: Will this type of welder, in addition to the automatic work and doing away with the human element, give a weld that will be as ductile as the parent metal, so that it will not break going through a cold reduction mill, or at least reduce the breakage experience we have today?

Secondly, what is the average time required on this type of machine to successfully complete a weld?

R. E. Morton: The time cycle element in this particular type of process is quite a variable. With a given strip it has been our practice (and our tests have shown that it is possible) to make such a weld in approximately one minute. There are so many variables involved that I would like to clear up one thing.

In any discussion of time element, the element of time we are talking about is that element of time within the machine itself. Cropping time, loading time, run-up time, are in addition to the time cycles mentioned.

I would say that on a specific strip of 0.100 in. thick, 48-in. wide, a complete cycle within 1½ minutes is entirely practical.

In regard to breakage, that is another never-ending subject for discussion. Percentages in themselves are rather confusing things. The compiled history of this type of welding, not only within our own limited experience, but throughout the industry, has not been compiled. I would venture a guess that, given reasonably good steel, and with processes controlled as we have outlined them in some form of mechanical equipment, I would expect breakage could be held well within one per cent.

Anthony H. Tohir: While we realize that the accuracy of preparing the strip, positioning, clamping and welding are all equally important, the speed at which these functions are performed is of utmost importance particularly in continuous processing lines.

The time cycle of the welder places limitations on the speed of the strip processing lines in which it is installed. In some continuous annealing processes, it is mandatory that the speed of the strip through the furnace be held constant at all times. In order that this condition be met, the welding cycle should be in the order of 30 seconds or less, for lines operating at about 1000 fpm, to keep looper pits or towers within reasonable limits.

What, is the average time for a welding cycle on lighter strip gages, that can be expected at present on machines of the type you have described?

R. E. Morton: Machine cycle time, as previously discussed, divides itself into two major elements: (1) mechanical handling of the strip and square shearing, and (2) making the actual weld. A typical example of such time on 0.014 silicon 48-in. wide with two torch operation would be a total of 1.0 minutes with welding cycle being 0.5 minutes and mechanical handling time accounting for 0.5 minutes.

M. D. Baughman, Jr.: Since our company has been closely associated with the development of continuous strip processing lines, we have always recognized the importance of a welding system to the successful operation of such lines. The welding requirements of a processing line vary to a great extent, and there have been many welding techniques developed to meet the conditions that have been established by the industry. Consequently, there is usually more than one acceptable welding method available for each line application, and the final selection must be based on serious consideration of such factors as first cost, operating cost, weld time cycle, effect of the weld passage through the process section of the line, and the complexity of strip preparation for welding.

For example, one of the more difficult welding applications in strip finishing is now done extensively in continuous pickling lines where high quality welds must be made to build up coil size for subsequent cold reduction. This has been successfully accomplished in the majority of the installations by electric flash butt welders such as the equipment developed by several equipment makers. The equipment described by Mr. Morton represents another method that fulfills the basic requirements of this application. In addition, there have been several installations where first cost was the important factor, and relatively inexpensive submerged arc type equipment has been successfully utilized.

Although the development of welding for cold reduction has played an important part in the progress of strip finishing lines, an equally important contribution has been made by the systems which were designed to accomplish rapid splicing of coils so that cold rolled strip can be continuously processed for sheet and tin mill products. In applications of this type, the quality of the weld is not as important a factor as is the weld-time cycle or the effect of weld passage through the processing section of the line. Similarly in this case, several machines and techniques are available such as seam welders, mash welders, lap seam welders, spot welders, submerged arc, shielded metallic arc and several others.

Although the two examples that have been cited represent two general catagories of process welding, there are of course many other special applications where the requirements are dictated by such factors as: special types of material, wide range of gages, and the end use of the welded joint. Some of the methods that have been mentioned previously, and the equipment described by Mr. Morton are applicable to these special applications.

These comments have been offered to point out that there are many welding systems available and further development work is being done.

Further design and development work is necessary in order that the welding systems can keep in step with processing line progress toward higher speeds and more automation.

TONNAGE HEATING BY INDUCTION

By MICHAEL C. D. HOBBS
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▲ ELECTRICAL induction heating differs from conventional furnace heating in that the heat is actually generated inside the body to be heated. It differs from electrical resistance heating in that there is no contact between the source of electrical energy and the work. Energy is transferred from the electrical inductors to the work by means of a magnetic field, and the conductors themselves remain cold. Any electrically conducting material may be heated by this method.

ADVANTAGES OF THE ELECTRICAL INDUCTION METHOD

Because electrical energy is used it is relatively easy to provide a flexible accurate control. Power may be turned on or off or modulated automatically or at the touch of a button.

The installation can be simple and compact; since the heating coil itself remains cold, practically no heat need be dissipated into the surrounding area and it is possible, with complete comfort and safety, to approach within a few inches of the ingot or work in the coil even when it is at maximum temperature. Consequently this method lends itself to automatic handling.

The heating is rapid and so provides minimum exposure of the heated surface for scaling and decarburization. Also it is generally relatively easy to provide a protective atmosphere should that be desirable.

Power consumption on well designed installation should run in the order of 300 kw hr per ton of steel heated. This figure is approximately correct for most grades of steel including stainless, provided the proper relationship is maintained between size and frequency.

CHOICE OF FREQUENCY

For any given piece of material at a given temperature, there is a theoretical optimum frequency. This optimum frequency will provide the maximum heating rate, the best power factor, and best overall efficiency. This theoretical optimum frequency may be calculated if size, resistivity and permeability of the parts are known. In practical terms, cost may well be a major determining factor in the choice of frequency since the capital cost of a plant increases rapidly with increasing frequency.

When heating steel and considering all four factors, that is size, resistivity, permeability and cost, it is generally found that with material 6 in. square or larger, it is practically and economically feasible to do this work with 60 cycles alone.

With magnetic steels, a very large change in permeability occurs when the steel passes through the Curie point, that is changes from the magnetic to the non-magnetic state at about 1400 F. Thus a frequency which would be ideal for the magnetic state is no longer as suitable for the non-magnetic condition. Consequently with steel in the range of sizes from about 1½ to 6 in. square, the best economic and overall operating conditions are achieved with use of two frequencies, that is 60 cycles below the Curie point and a somewhat higher frequency above that point. In actual practice it is found that under these conditions, approximately one half of the power can be applied at 60 cycles and the balance at a higher frequency. Such an arrange-

. . . . induction heating has important applications in tonnage production . . . . important factors are that it offers solutions to problems which involve mechanization, space and working conditions . . . . in many cases adoption can be justified on costs alone . . . .

ment is less expensive than an all high frequency plant and generally offers some improvement in overall efficiency, since only one half of the total power need be passed through the frequency converting equipment with its inevitable losses.

ECONOMIC CONSIDERATIONS — INDUCTION VERSUS FUEL

Assuming that power is available at approximately 1¢ per kwhr and taking into account only those obvious operating costs which are easily determined, the following is suggested as a yard stick for evaluating a situation for a possible application of induction heating:

If the cost of fuel, plus scale loss, plus labor, plus maintenance, plus overhead on the fuel-fired operation would be $4.00 per ton or more, then one would be justified in considering induction heating.

There are, of course, many other intangible factors which are difficult to evaluate directly in dollars. Such factors might include advantages made possible because of the small amount of work actually in process in an induction heating installation. The induction heating furnace generally occupies a relatively small amount of space and can be mechanized more easily than most other heating systems, consequently it is well suited to use in a production line. Frequently a very decided advantage can be achieved with induction heating through the production of scale free billets. It is quite safe to say that no other form of heating can give the excellent working conditions which are possible with an induction heating plant.

SPECIAL APPLICATIONS

There are, of course, those applications where induction heating is peculiarly adaptable, since it makes possible heating which cannot be readily accomplished by other means. Shell nosing might be a case in point where the induction method provides rapid scale free heating which is easily adapted to the production line and, at the same time, gives a controlled heating pattern which is essential to the accurate forging of the shell nose.

Induction also offers advantages in those cases where rapid uniform heating is essential. In this connection, the illustration below will show how, by actually generating the heat inside the billet, the induction heating process can give more uniform and better heating conditions in a given length of time than can be achieved in, for example, a salt bath furnace. See Figure 1.

In connection with special conditions as applied to tonnage heating by induction, mention might be made of strip heating. It should be pointed out immediately that the technique of this process is not nearly so far advanced as is the art of billet and ingot heating. However, laboratory work has shown that this field offers great promise. It appears that it may be possible, for example, to apply the heat required for annealing to work in process since a great deal of energy can be applied in relatively small space. Even reheating between rolling operations may be feasible. In such cases, the cost of fuel is of secondary consideration; but it is pointed out that such relatively low grade fuels as blast furnace gas might be burnt in gas turbines which would then drive the generators to provide power for the induction heating process. It is suggested that this approach could provide an overall thermal efficiency of better than 15 per cent.

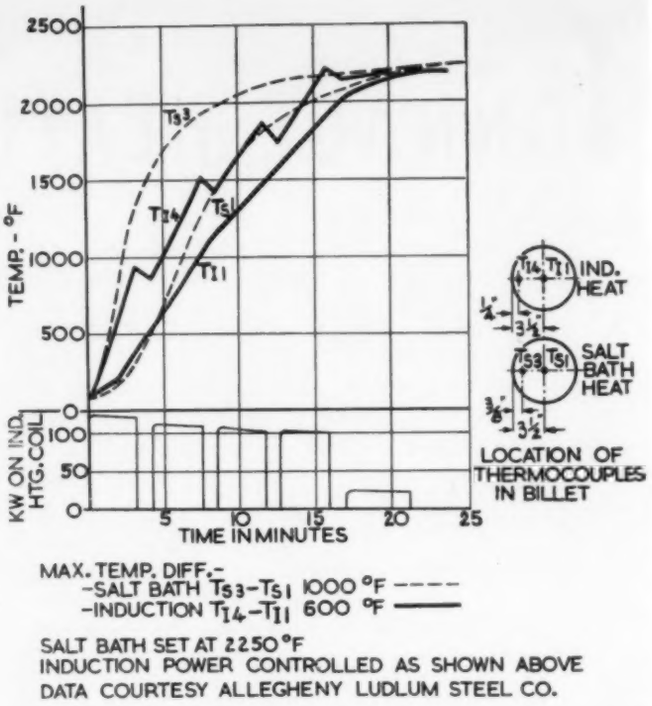


Figure 1 — A comparison of salt bath and induction heating on 7-in. diam billets of 304 stainless steel shows smaller temperature differences in the billets heated with induction.

CAPITAL COST

The capital cost of an induction heating installation for heating ingots and billets will vary rather widely depending on conditions, but it is generally in the order of $50 to $100 per kw of installed capacity. With power consumption running in the order of 300 kwhr per ton, this means a capital cost of $15,000 to $30,000 per ton per hour of capacity.

One of the largest single items of capital cost for tonnage heating by induction is involved in the capacitors for power factor correction. It is conceivable that further developments in capacitor design and construction might lead to reduced costs.

POWER COST

Since for 100 per cent efficiency the power requirements are approximately 200 kwhr per ton, it would not appear that the power consumption figures as now achieved could be reduced by any great amount, and in most places power will continue to cost from $1.50 to $4.00 per ton of steel heated.

TYPICAL INSTALLATIONS

1. *Canadian Car & Foundry Co.*—One very successful tonnage induction heating unit has been in operation in the plant of the Canadian Car & Foundry Co., Montreal, Canada. This unit is heating 6-in. square mild steel billets for forging into 155-mm shells. It has replaced two oil-fired rotary hearth furnaces, one of which was used in production while the other was held as a standby.

The general arrangement of the plant is shown in Figure 2. This is an all 60-cycle installation so that it was relatively low in first cost and has given good efficiency. It required rather less than one quarter of the space formerly occupied by the rotary hearth furnaces and is fully automatic. Hot ingots are discharged at a uniform temperature and uniform rate and practically scale-free. This has made it possible to increase production, improve the quality of the product and reduce maintenance on dies and forging equipment, all as shown in the tables below. Furthermore, there has been a very great improvement in working conditions, but as usual it is difficult to evaluate this in terms of dollars. The following summarizes data on this plant:

Capital cost—completely installed—less than $100,000.00.

Billets—6 x 6 x 12½ in.—130 lb.

Production—50 to 55 pieces per hour.

Power consumption—1100 kw—330 kwhr per ton.

Operating labor—2 billet cutters, 1 furnace man.

Maintenance—1 man, 5 hours per day (between shifts).

Savings compare with previous experience with oil fired rotary hearth as follows:

Labor—3 men per shift.

Scale—3 lb per billet were previously lost, this is now practically nothing.

Die life—increased 60 per cent.

Draw ring life—increased 150 per cent.

Working conditions are greatly improved.

Full production (400 pieces per shift) accomplished with much less overtime than was previously required.

Induction furnace occupies about one quarter of the space formerly taken by oil fired furnaces.

The steel enters the plant as rolled bars which are flame cut to the desired length. Cut billets travel on a gravity conveyor to the feed end of the induction heating furnace. This gravity conveyor also serves as a surge bin with a storage capacity of some 50 or 60 prepared billets. An elevator lifts the billets from the gravity conveyor and discharges them into the feed mechanism of the induction heating furnace. This feed mechanism is operated hydraulically and pushes the billets in a continuous line through the induction heating furnace. The furnace is kept full at all times and a hot billet emerges as a cold billet enters at the feed end. A radiation pyrometer is used to measure the temperature of the billets as they are discharged and also to control the power, turning it on or off as required to maintain the preset temperature. Live rollers at the discharge end of the furnace assist in moving of the hot billets and start them on their way down a gravity conveyor which discharges them to the forging die.

It might be noted that these billets could have been fed through the furnace side by side rather than end to end, and the side by side arrangement would have reduced the length of the coil tunnel by about one half. It would have been, however, more awkward to handle the billets from a side by side position in this case and, consequently, the end to end arrangement has been preferred.

Figure 2 — General arrangement of induction heating plant operated by Canadian Car and Foundry Co., Montreal, Canada

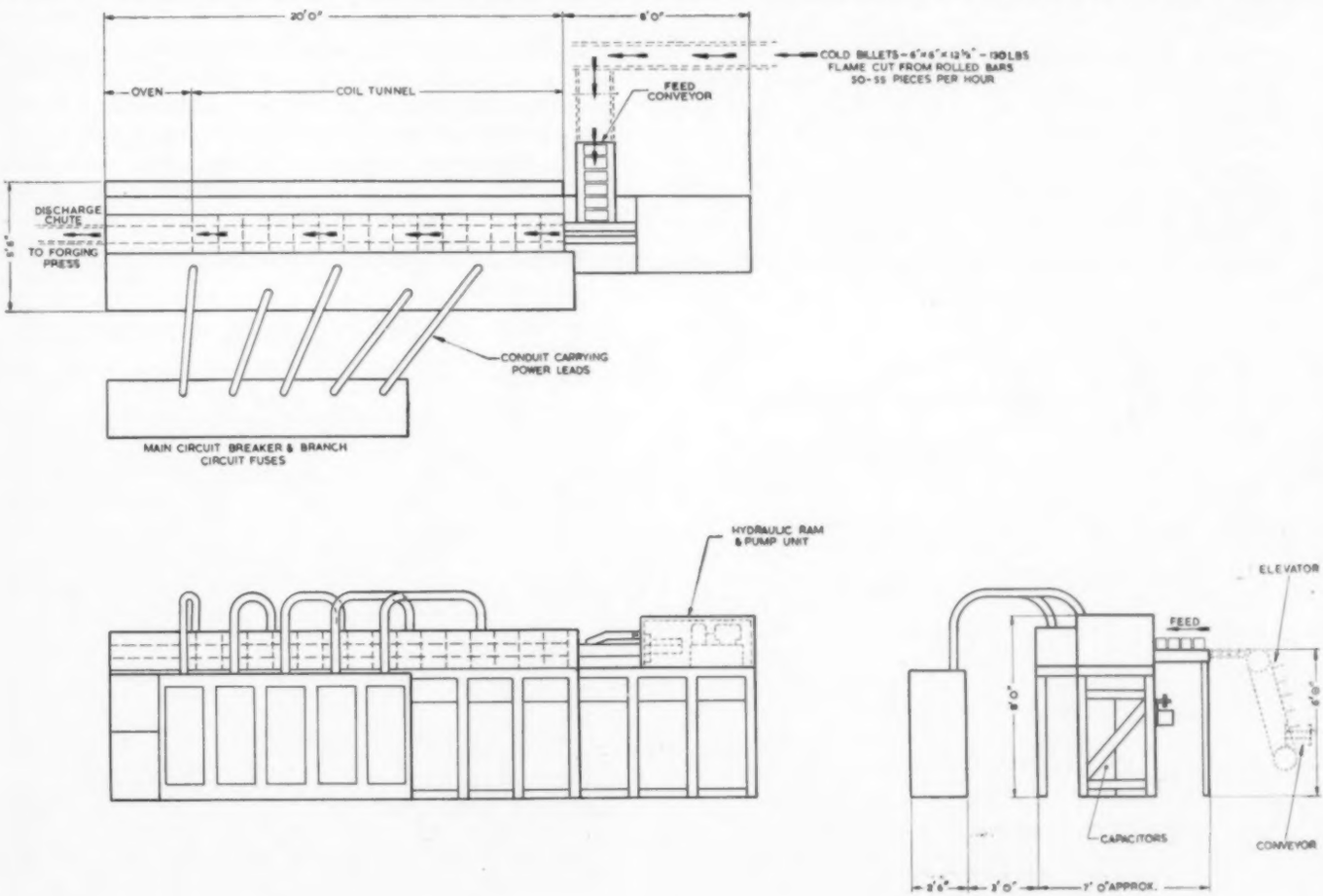


Figure 3 — Induction heating operation is supervised from the control pulpit.

2. *Vancouver Rolling Mills Ltd*— What is believed to be the largest single induction heating installation in the world is to be found in the plant of the Vancouver Rolling Mills, Vancouver, Canada. This is a dual frequency installation and is used to heat cast steel ingots for rolling. The installation is also unique in that it is the first time the electrical induction heating method has been used for heating ingots in a rolling mill.

In this installation also, the ingots are pushed in a continuous line, end to end, through the heating tunnel. To keep the overall length of the unit within reasonable limits, it was designed as two identical parallel tunnels and this arrangement also provides some increase in flexibility since either side may be operated independently. A determined effort was made to keep the construction simple and rugged to facilitate maintenance and to ensure uninterrupted operation.

Ingots are brought as required from the storage yard by fork lift trucks which place them on a table fitted with walking beams. These spread out the bundles of ingots and advance them to another table fitted with flat rubber belts which carry the ingots forward to the hydraulically operated feeder. The feeder distributes the ingots one at a time as required to each line, where hydraulic rams push them through the troughs into the heating tunnel. Interlocks keep the two lines in step so that ingots are fed to the mill at regular intervals.

The operation is supervised from a pulpit which has been set up between the two lines and above the furnace, so that the operator has a good view of both ends of the furnace and also down the length of the mill (see Figure 3).

From this control pulpit the operator can adjust the rate of feed and power input as well as the power driven roller conveyor which carries hot ingots from the end of the furnace to the mill. In addition, there is a gate provided in this conveyor with a control so that the operator may direct ingots to the mill or set them aside.

Meters are provided which indicate the current, voltage and power in the various circuits. Radiation pyrometers sense the steel temperature at the end of the 60-cycle zone, and at the middle and end of the high temperature zone. These temperatures are shown on appropriate meters in the control pulpit.

The furnace was required to heat a range of taper cast ingots which vary in cross section from 3-in. square to 6½-in. square. Consequently it was necessary to employ two frequencies to achieve acceptable efficiency. Approximately one half of the line is supplied at 60 cycles and the balance at 540 cycles.

Power for this furnace is brought into the plant at 60,000 volts and stepped down in three 3,000-kva transformers to 4,000 volts. Power for the 60-cycle end of the furnace is stepped down again from the 4,000 volts to 550 volts in a 4,000-kva, three-phase transformer with off-load tap changing equipment.

The high frequency power is obtained from a 3500-kw alternator driven by a 5,000-kva synchronous motor which is operated at 4,000 volts.

Figure 4 — Production flow at the Vancouver Rolling Mills plant is given by this schematic.

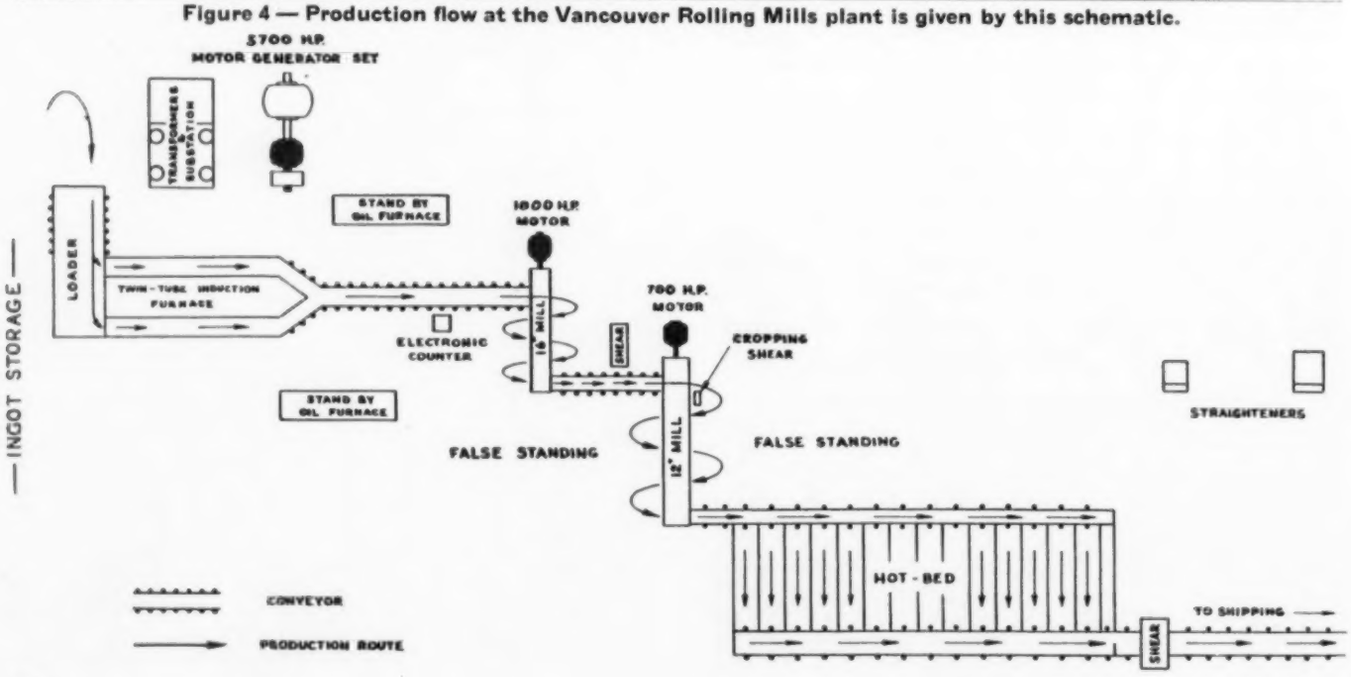


Figure 5 — Feed end of induction heating furnace.

Conventional air-cooled capacitors are used for the power factor correction in the 60-cycle end, and the power factor is corrected to approximately unity under most conditions. The capacitors used for the high frequency coils are water cooled and the power factor is held to unity or slightly leading.

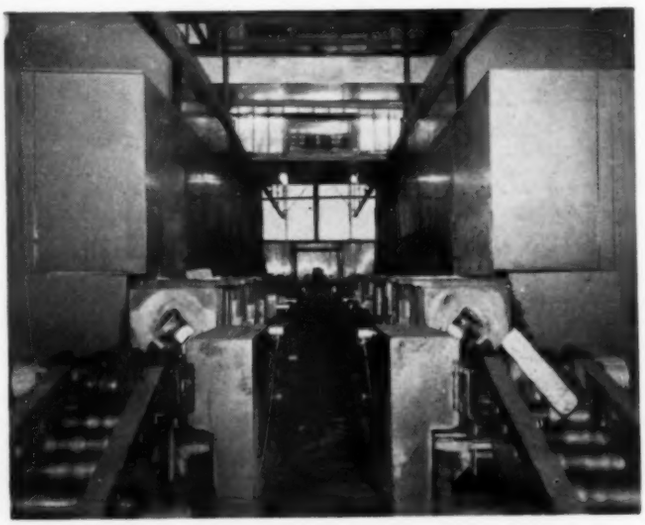
Temperature control is achieved by changing the high frequency voltage which is accomplished very easily by adjusting the generator field current.

Watt hour meters have been installed to measure the power delivered from the 4,000 volt bus, and it has been established that the power consumption on the largest ingots is approximately 300 kwhr per ton or better including all losses. The largest ingots are heated at the rate of 20 to 25 tons per hour. With the smaller ingots, the average power consumption is somewhat higher and the rate of flow somewhat less.

One of the most striking features of the new operation is its speed. The total heating time ranges from 3.6 minutes for the smallest ingots to 8.4 minutes for the largest. Something less than a total of 10 minutes elapses from the time the large ingot enters the furnace until it is a finished bar on the cooling bed. Thus there is a relatively small tonnage of material in process at any time, and the furnace may be started or stopped practically at the touch of a button.

A closed circuit cooling water system is employed using a cooling tower of the multi-baffle type. This provides the necessary water for cooling the 60 and 540-cycle coils, the 540-cycle capacitors, the 3000-kva transformers, and the 540-cycle alternator. Maximum flow in the cooling water circuit is approximately 500 U. S. gpm.

Figure 6 — Discharge end of induction heating furnace.



The general arrangement of the furnace in the plant is shown in Figure 4. Figures 5 and 6 are pictures of the feed and discharge ends of the furnace.

This furnace has been in continuous use for over a year with very gratifying results.

The furnace operates with a total of four men per shift and higher production rates than those presently achieved will not require an increase in the crew. The working conditions of the crew have improved immeasurably as compared with the former operation with the fuel-fired furnace. They are at no time subjected to heat and can work in perfect safety and comfort throughout the operation.

The problems encountered in putting this unit into operation were not out of proportion considering its size and uniqueness. Because of its size, any testing prior to the completion of the installation was necessarily limited. Heating tests were limited to a single ingot and it was quite impossible to duplicate operating conditions even approximately.

The major operating problem arose from the fact that this was a pioneer application. Since it was new, there was no bank of previous experience upon which to draw and while, ultimately, the operation and maintenance was reduced to simple straightforward routine, this had to be developed in actual production. Consequently all the expected benefits from the new furnace were not realized immediately. However, the production was maintained on the new unit from the very start with increased efficiency as the crew became more experienced.

As compared with the previous fuel-fired furnaces, the installation requires approximately 160 fewer manhours per shift. In addition, the production of finished steel has been increased by an average of approximately 30 per cent as compared with the previous operation. Electrical energy used costs approximately $1.00 per ton less than the previous cost with fuel oil. The indicated scale loss has been reduced from an estimated 3 to less than 1 per cent. This has also resulted in a better finish on the final product.

THE EFFECT OF SOAKING AT TEMPERATURE

As a matter of interest it might be reported that extensive tests were run to determine the effect of soaking on the rolling qualities of the cast steel ingots. Strain gages were installed under the holddown screws in the breakdown mill and careful measurements were made of the pressures developed in this mill when rolling ingots which had been heated under a variety of conditions.

Ingots which had been taken from the induction heating furnace with a minimum heating time were compared with other ingots which had been heated and then held at temperature in an oil-fired furnace for various periods up to several hours. It was found that so long as the steel was at the same temperature as the mill, there was no difference in the pressure developed or in other rolling characteristics between the

steel which had been heated most rapidly and other ingots which had had various lengths of soaking at the rolling temperature. This test showed conclusively that within practical limits, full advantage can be taken of the most rapid heating available with induction heating without affecting the rolling operation. Earlier tests with rolled steel billets used in shell forging had given similar results, but these are the first tests to be conducted with cast structure.

SUMMARY

It may be stated that, in addition to its widely accepted use for special small jobs, induction heating has an important field of application for large scale heating. There are applications where its use can be justified on obvious economic grounds alone, as well as many others where it can provide the best solution to particular problems, such as those involving mechanization, space and working conditions.

APPENDIX A

Some details of tests to determine the effect of soaking and temperature on rolling characteristics, roll pressure required and roll wear.

During the operation of this unit, an attempt was made to increase the tonnage throughput beyond the furnace's capacity. A reduction in temperature was naturally experienced, but the rate of roll wear increased suddenly with production dropping from 907 tons per $\frac{1}{16}$-in. dressed from roll to 353 tons per $\frac{1}{16}$-in.

It was felt and expressed in most instances that the absence of scale and soak were the cause of excessive roll wear, the furnace providing less than 1 per cent scale in normal operation.

We knew that there was an increase in roll pressure by the working of (cold) steel and set about to determine the increase in pressure for each 100 F drop below 2250 F.

A series of tests were decided upon using strain gage dynamometers, and Professor W. O. Richmond, Head-Dept. of Mechanical Engineering, University of British Columbia, was retained to set up recording equipment and supply the cells. He had a major problem to overcome, that of designing or locating recording equipment with a high chart speed and sensitive enough to record peaks without over-shooting. His work is given in a report, "Notes on Measurement of Roll Force by Strain Gauge Dynamometer" from which the following is taken:

The force tending to separate the rolls was measured by placing load cells consisting of hollow steel cylinders 4 in. outside diam, 3 in. inside diam and 4 in. long. The bottom of the cylinder fitted into the bearing plate for the hold down screw, while a steel cap was placed on top of the cylinder to transfer the pressure from the screw. The steel cylinders were thus placed in axial compression.

Four SR-4 type A5-1 strain gages were cemented to the outer surface of the cylinder. Two of these were placed axially on opposite sides of the cylinder and two were placed circumferentially. The four gages were connected in a Wheatstone bridge circuit, the unbalancing of which could be read either in a strain indicator or by means of a strain analyzer and pen and ink oscillograph. An outer sheet metal covering was provided to protect the gages and they were coated with wax to guard against moisture penetration. Shielded leads were used to connect the load cells to the instruments and these were kept the same length for each cell. The load cells were calibrated in a testing machine. It was originally intended to connect the two load cells in parallel to the instrument so that a reading would be obtained proportional to the average load carried by the two cells. Thus the force tending to separate the rolls would have been measured. Unfortunately just prior to the test a bar cobble carried away one set of leads. Thus only the force on one side of the roll stand was measured. This was satisfactory since comparative results were all that were required.

It was thought that it might be possible to measure the roll force by manually balancing the strain indicator. It was found impossible to do this due to the variation of force during the rolling process. The strain analyzer and pen and ink oscillograph provided a very satisfactory record of the roll force variations.

The tests were conducted in the following manner:

A. Two optical pyrometers and two radiation pyrometers were used to achieve as accurate an average temperature reading as possible. After each ingot all readings were checked. All averages remained constant throughoutt the tests.

The induction furnace was run at normal operating speed for two hours, before any trials were attempted.

B. The test trials were run 10 minutes apart to allow sufficient time for the furnace to equalize to the change or new ingot temperature.

C. The range of temperatures to be run was 2250 to 1700 F. The actual range covered was 2200 F to 1700 F.

D. An oil-fired test furnace was constructed for purposes of comparison to allow lengths of soak at a steady temperature to be maintained for periods from 30 minutes to 2 hours.

E. Twenty separate tests were run consisting of ten ingots of one heat per test and groups of three ingots were heated for comparison in the oil furnace and soaked at the temperature of the preceding induction test. Periods of soak were increased from $\frac{1}{2}$ to $1\frac{1}{2}$ hours.

Briefly the summation of results are:

The ingots electrically heated and oil heated fell into same position on the graph provided the temperatures were equal. Variations were experienced through short carbon variations and some temperature variations. To further check temperature variations, two optical pyrometers recorded the temperature through each of three passes per ingot and some variation showed through this test.

The graph shows the rate of climb in load: at 2100 F the average load on three passes was 97,000 lb, at 2000 F the average load on three passes was 124,000 lb, at 1950 F the average load on three passes was 142,000 lb, at 1900 F average load on three passes was 177,000 lb.

Correspondingly, the roll shops report on roll life shows a decrease in life during production periods when the furnace is beyond capacity and rolling cold steel of 353 tons per $\frac{1}{16}$ in. of dressing as against an average of 907 tons per $\frac{1}{16}$ in. of dressing when using 1.25 carbon, 1.25 Cr, 0.40 Mo rolls.

Obviously the very great increase in roll pressure required for a reduction of 200 F in billet temperature

could account for the observed sharp increase in roll wear, and contrary to earlier opinion, conditions such as length of soak, scale, etc., do not appear to be important factors.

DISCUSSION

PRESENTED BY

D. C. McCRADY, Supt. Electrical Dept., The Steel Co. of Canada Ltd., Hamilton, Ontario, Canada.

J. F. REIS, Electrical Engineer, Jones and Laughlin Steel Corp., Cleveland, Ohio.

R. S. SEGSWORTH, Director of Research, Production Heat Div., The General Engineering Co., Toronto, Canada.

D. C. McCrady: I would like to know what tolerances are required as regards straightness of billets. What clearances are tolerable in the induction heating tunnel and for what length of billet?

I would also like to know a little bit about possible maintenance problems which might arise in connection with the ceramic envelope for the heating coils.

I would also like to know what range of billet sizes can be heated with any single furnace lining setup.

Also, I wondered what protection is provided in the event that a cobble occurs, or for some other reason, feeding of a billet comes to a stop. What method is used for holding the steel temperature down to reasonable limits?

R. S. Segsworth: Those are very practical questions. With regard to straightness, it is a little difficult to answer in general terms. The maximum electrical efficiency is achieved when you have the minimum clearance between the coil and the work. It is a matter for study in each application to determine how far one would be prepared to sacrifice efficiency to accommodate crooked parts.

In the installation in Vancouver, the largest pieces that are fed are 6½ in. square. The inside dimension of the tunnel is 7 in. square. The smallest pieces that are fed have a minimum section of 3 in. and a maximum section of 4 in. The efficiency on the small pieces is obviously not as good as it is on the large ones. Also, the production capacity of the furnace is less on the small ones than it is on the large ones.

The maintenance, particularly as applied to coils, can be a considerable problem. I think the results achieved by Mr. Hobbs will indicate that an acceptable, practical solution has been developed. The problem is difficult. One would like to have the hot steel not more than half an inch away from the conductors in the coil which would be carrying current at 400 to 600 volts. However, the cast type of structure which we have adopted with the modern ceramic liners which are available do stand up quite well in service.

In Vancouver, there are about 60 coils in use. These coils are relatively small so they are easily serviced. The plant works on a two-shift basis and five coils are removed from the line every 24 hours for servicing. The servicing involves blowing out the dirt, patching up any broken spots in the ceramic, and once in a while, recasting. One man at Vancouver handles all this maintenance work and production interruptions due to furnace troubles are rare.

To take care of mill holdups a gate has been provided in the discharge conveyors so that it is easy to set ingots aside. In addition to that, the operator has a telephone and the head roller can tell him about the length of the stoppage so that he can adjust the feed rate and the power input to his unit so that he discards a minimum of ingots during the stoppage. He will perhaps cut the feed rate down from one or two or three per minute, whatever they are doing, to a small fraction of that. Only in the event of a long stoppage would he shut the furnace off entirely. The reason for that is that the pyrometers are sighted on the work in the gaps between the coils and if the feed is shut off completely, the pyrometer has no control. But, as long as the work moves even quite slowly, the pyrometer indicates the temperature, the work is under control. Once an operator has had a little experience, the furnace can be stopped and started with little trouble.

J. F. Reis: Does the author contemplate or has he made the necessary calculations and design to use induction heating to increase the temperature of slabs delivered by a modern high lift, high speed slabbing mill to permit direct rolling through a hot strip mill?

Assume that the plain carbon or light alloy steel slabs were of 4 to 8 in. thick, 36 to 66 in. wide, and of 24 to 40 or 50 ft long. Further, assume that the slab had passed through a descarfer (all sides) and sheared, front and rear, before entering the heating equipment.

Would Mr. Segsworth discuss the use of induction heating, is it practicable and economical, approximate heating time, space requirements, what are the electrical power characteristics, what are the heating energy costs per ton, give limitations and advantages, etc., for the above slab heating requirements? Also, have any such applications been made or are any plans being developed for such use of induction heating?

R. S. Segsworth: There are no such applications in use so far as I know, but it looks as if it would be one of those places where further work would be justified.

The range of sizes you have mentioned make it possible to apply the energy without rotary equipment so that from that point of view it would be comparatively economical on the basis of capital cost. There are some problems not yet solved, or at least the solution is not yet fully demonstrated, in heating wide pieces uniformly. We believe it can be done and to support our belief, I might cite an illustration which is in operation, that is heating aluminum slabs for rolling. These are some 30 odd in. wide and about six in. thick.

We do not yet know the practical limits of coil width. That is, a rectangular coil introduces certain mechanical problems in holding the windings against vibration and the mechanical stresses which are developed as a result of the magnetic forces.

Based on our experience with billets and limited tests with steel slabs, it is suggested that the power required would be in the order of 12 to 20 kwhr per ton per 100 F temperature use. The lower figure applies in the lowest temperature range and the highest at higher temperatures.

Heating time would depend upon the thickness of the slab and the allowable temperature difference surface to center. Again based on our experience and limited tests with slabs, a figure of 100 F per minute might be considered for an 8-in. thick mild steel slab.

DEVELOPMENT OF AUTOMATIC THICKNESS CONTROL

PART I — APPLICATION

By H. S. MAXWELL
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▲ IN 1954 our company and United States Steel combined efforts to obtain a rolling operation which would produce a greater percentage of close tolerance strip. The No. 2, 5-stand mill at Irvin Works was well suited to our mutual purpose. The production pattern was well established, it was equipped with our motors and control, and it had been the subject of exhaustive tests in past years, making adequate data for system study available. Irvin personnel were anxious to install automatic control as a step toward improved quality and automatic operation.

With the aid of analytical and electronic computer studies, an automatic thickness control system was integrated with the existing electric drive. New equipment includes (Figure 1) two x-ray gages and two automatic control panels to adjust roll opening at stand 1 and roll speed at stand 5. Equipment also includes air operated retraction equipment for the gage heads, replacement operators' cabinets incorporating added instruments and devices, replacement brakes for stand 1 screwdown motors, a field current regulator for stand 5 mill motor, modifications to winding reel control and reconditioned tensiometers. Since the installation has been described in the trade press it will be reviewed only briefly.

Being a cooperative venture of importance, this development was the work of many people. The user's participants included mill production and headquarters research as well as works engineering. Engineering, sales and manufacturing personnel of several departments of the manufacturer's organization contributed to the development of the system.

COARSE REGULATING SYSTEM

A sampling action coarse regulator controls thickness leaving stand 1. A 50-kv gage with ranges 0.0500-0.0750 in. and 0.0750-0.1000 in. and deviation indicator range 10-0-10 ten-thousandths is suspended from a monorail immediately after stand 1 (Figure 2). Thickness deviations cause operation of stand 1 screwdown motors in the proper direction to correct the error.

Some single stand mills had been equipped with x-

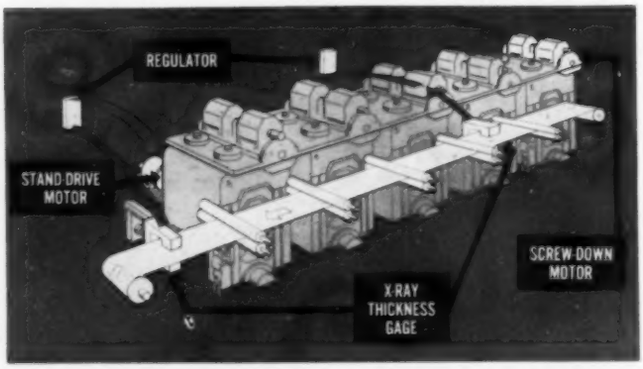
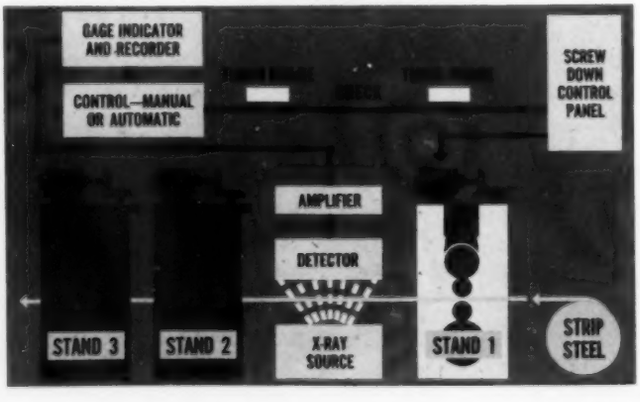


Figure 1 — Block diagram of the automatic thickness control as applied to the Irvin No. 2, 5-stand, tandem, cold strip mill.

Figure 2 — Block diagram shows the automatic thickness control system for stand 1. The timed pulse on-time is variable and is a function of the deviation from the desired strip thickness. Off-time is also variable and inversely proportional to strip speed.



Automatic thickness control is a marked advance which the steel industry can use to obtain more uniform quality in its product . . . . equipment has emphasized advantages and reliability of transistors . . . . manual control has been reduced to a minimum and quality will be less subject to human variation.

FOR TANDEM COLD REDUCTION MILLS

ray gages and sampling action regulators actuating screwdowns for about ten years. Electronic equipment manufacturers had also applied such regulators to the first stand of other tandem mills for several years. Substantial improvement in strip thickness between stands 1 and 2 had been obtained with this equipment. The Irvin equipment incorporates refinements in timing and error sensing, and modifications of the usual magnetic screwdown control which permit holding gage out of stand 1 to much closer tolerances, usually within plus and minus 0.0007 in.

More frequent operation of the magnetic contactors of the screwdown control has not resulted in high maintenance. Preset limits which initiate screwdown operation are necessarily set wide enough to avoid excessive contactor operation or motor heating. Future controls for new mills with variable voltage screwdown control are expected to permit holding closer tolerances.

VERNIER REGULATING SYSTEM

A continuous action vernier regulator controls thickness leaving stand 5. A second 50-kv gage with ranges 0.0050-0.0175 in. and 0.0175-0.0300 in. and deviation indicator range 5-0-5 ten-thousandths is suspended from a monorail immediately after stand 5 (Figure 3). Thickness deviations cause changes in speed of the 3000-hp stand 5 motor, increasing speed to correct plus deviations and decreasing speed to correct minus deviations.

An increase in stand 5 motor speed increases back tension and momentarily decreases front tension. Required roll pressure is reduced according to the theory of plastic flow and rolls and mill housing, acting like a large spring, decrease the roll opening and thus delivery thickness.

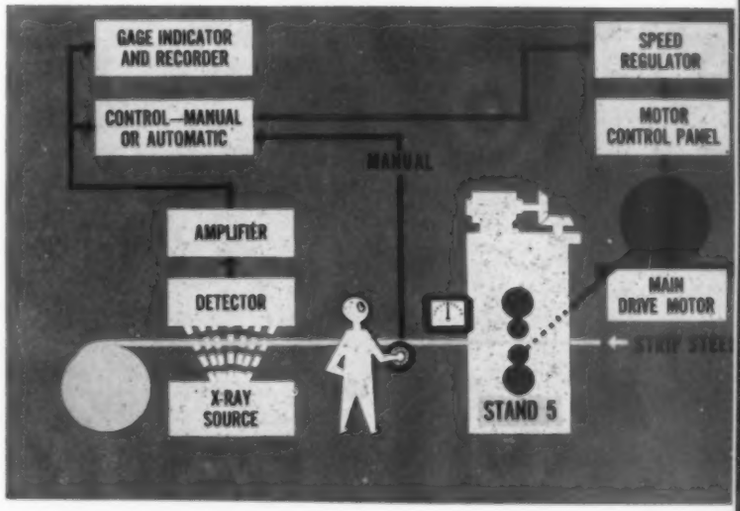
Obtaining a continuous regulator, one which recognizes no tolerance and acts on any deviation from desired thickness, with sufficient gain for substantial reduction of thickness errors while maintaining stability, was more difficult than obtaining a suitable coarse regulator. The vernier regulator required considerable analytical study both before and after installation. Although present operation is quite acceptable, computer studies in process are exploring possibilities of further improvement.

With delivery speeds exceeding 60 fps the ability of the x-ray gage to respond to a step change in thickness in approximately 0.2 second was important. Although a slower gage might be acceptable, using different regulator circuitry, flexibility in adjustment for best results is possible when the response of the gage is not limiting.

INSTRUMENTS AND CONTROLS

The automatic thickness control for stand 1 includes a screw reset regulating system to insure consistent results between coils of the same order and to eliminate a chore for the stand 1 operator. When starting the first coil of an order, before selecting automatic control, the stand 1 operator sets the roll opening under manual

Figure 3 — The vernier automatic thickness regulator for stand 5 continuously controls draft, recognizing no tolerance and acting on any deviation from desired thickness. Stand 5 operator is shown holding thickness during manual operation by adjustment of stand 5 motor field rheostat while watching a deviation indicator. With the vernier regulator in operation he is relieved of this tedious work.



control to a position which, from his past experience, will permit the remaining stands to bring the finished strip on-gage during the early part of the mill accelerating period. After the strip has been rolled under automatic control, as soon as the tail leaves stand 1, the roll opening is automatically returned to this position, ready for the next coil. Upon a change of order the operator may deselect automatic control and preset another roll opening.

Both gage heads are retractable by air cylinder to points clearing the mill housing and retractable by hand to service areas. The operator turns a switch to retract stand 1 gage head as the tail of each strip passes to clear the interstand area for threading the next strip into stand 2. Stand 5 gage head remains in gaging position unless operator retracts it because of inspection or repair to mill or gage.

At the beginning of an order, operators at stand 1 and stand 5 cabinets hold x-ray gage control switches in "Raise" or "Lower" position while pointers move to desired settings on gage indicator dials. The 50-in. length of scale for total range permits these settings, which serve as references for the thickness regulators as well as indicating and recording equipment, to be quickly set with high accuracy.

As the mill is threaded, bringing strip into the throats of the gages, the pointers of smaller indicating dials at several cabinets stand at center if strip has the preset value of thickness or deviate to right or left of center if strip is too thick or too thin, reading directly in ten-thousandths.

When strip is not being rolled a steel test plate, located within each gage head, may be brought into the measuring x-ray beam by operation of a selector switch. Operators can check whether either gage is measuring accurately by setting the gage indicator at test plate thickness. If the deviation indicator does not show zero, the operator can bring the reading to zero by turning a potentiometer, thus recalibrating the gage.

A screw departure indicator on stand 1 cabinet measures the direction and amount of screw travel occurring under regulator action. The initial position set by manual control is always the zero center position of the indicator. When screw position is reset by manual control upon change of order, the new screwdown setting becomes the zero.

Experience dictates how much the automatic control can be allowed to raise or lower the screws from a zero position without causing trouble. Preset limits prevent the regulator from increasing roll opening to the point of roll slippage or decreasing it to the point of overloading the stand 1 motor and stopping the mill.

For efficient operation cabinets at stands 1 and 5 were replaced with new operators' cabinets incorporating duplicates of the original operating controls for manual operation in their familiar positions together with the dials, switches, instruments and lights required for automatic control. See Figure 4.

At stand 1 the indicating lights show the operator at a glance whether control is under manual or automatic operation, whether the screwdown control is energized, whether strip thickness is light, on gage or heavy, whether preset limits of screwdown travel have been reached, whether an overload of stand 1 mill motor has occurred, and whether the regulating equipment has misoperated, requiring inspection.

The regulator inspection function continuously monitors the regulator operation to determine that the regulator is reducing deviations requiring screw operation to values within the preset limits in acceptable, preselected length of time. If not, control is automatically transferred to manual operation and the regulator is locked out of service until released by an electrical inspector. The lengths of time allowed for proper regulator operation are a function of mill speed, being shortest at top speed. As x-ray gages contain vacuum tubes which may occasionally fail without warning, some off-gage strip may be rolled when such failures occur. This is expected to be of minor importance, however, as compared with the benefits obtained from automatic control. The inspection feature should limit the off-gage to that which can be rolled within the few seconds monitor time.

Since the vernier regulator has a limited range of speed control, a speed departure indicator on stand 5 cabinet shows the zero of regulator operation. When the zone approaches plus limit or minus limit on the zero center instrument the operator readjusts the coarse or vernier rheostat.

Minimum and maximum limits of tension desired

Figure 4 — Operator is watching deviation indicator and indicating lights of stand 5 vernier thickness regulating system.

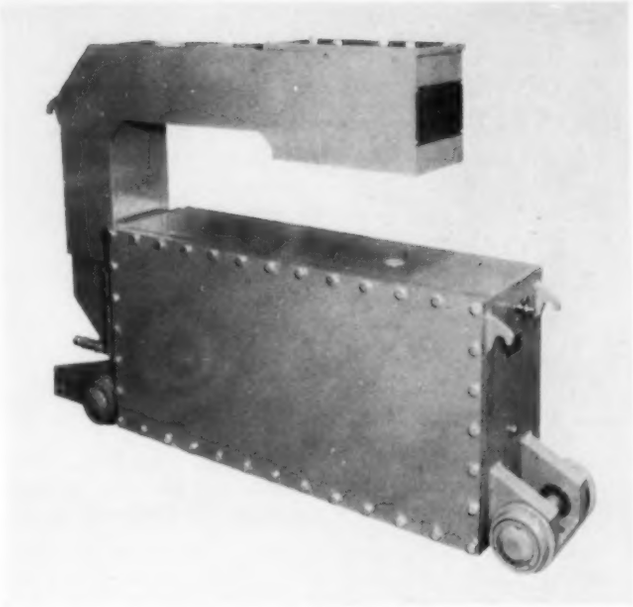


Figure 5 — The 50-kv x-ray thickness gage is an important unit in the system.

between stands 4 and 5 are preset. During either manual or automatic operation, indicating lights call the operator's attention if a limit value is reached. Other lights show whether strip is light, on-gage or heavy, whether control is under manual or automatic operation, whether regulator is in range, whether an overload of stand 5 motor has occurred, and whether the regulator has misoperated. In accordance with operator preference, an overload does not cause transfer to manual control. Decrease of tension below the preselected minimum while the mill is up to speed, however, causes automatic transfer to manual operation. Misoperation causes both transfer and lockout, as for the coarse regulator.

Regulator selector switches of both the coarse and vernier regulators may be left in automatic position at all times. Transfers to manual operation, as shown by the indicating lights, are made automatically in case of emergency stop, retraction of gage head, or loss of power supply to x-ray gage.

Since automatic control places full dependence on maintained accuracy of thickness measurement it becomes extremely important to use gages (Figure 5) having high accuracy, high sensitivity and low drift. Gages used are more complex than many others in order to obtain these characteristics. Each gage contains two continuous regulating systems for this purpose.

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PART II — DESIGN

By M. W. CANNON

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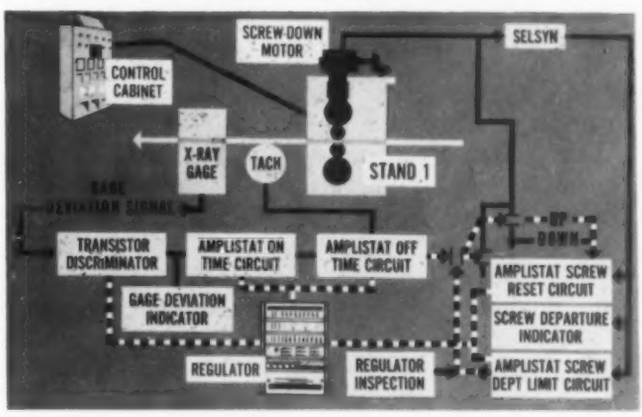
▲ *COARSE regulating system*—The coarse regulating system is a sampling type of regulating system rather than a continuous type of regulator as is normally used in regulating generator voltage or motor speed. This is necessary because the x-ray gage is located some distance from where the correction thickness is being made. This distance between the x-ray gage and stand one work rolls produce a time delay which varies as the speed of the mill changes, becoming approximately five seconds at thread speed. If a continuous type regulator were used the system would be unstable or would hunt, particularly on the lower speed mills.

Figure 6 shows the coarse regulator with the auxiliary functions included. The main functions are: (1) measurement of the steel strip thickness by the x-ray gage; (2) detection of thickness deviation from desired thickness both in polarity and magnitude; (3) amplification of the error signal; and (4) operation of the screwdown motors in the proper direction and for the proper lengths of time as determined by the sampling portion of the control circuits.

The remainder of the functions as shown on Figure 6 are not absolutely necessary to the operation of the coarse regulator, however, they are incorporated into the control in order to produce a complete coordinated drive including all the desirable features necessary to obtain maximum on-gage material while furnishing maximum information to the operators and protection to the equipment.

Discriminator—The thickness deviation signal obtained from the 50-kv x-ray gages is an a-c voltage varying in phase and magnitude from zero volts at

Figure 6 — On the coarse automatic regulating system on stand 1, the plus or minus thickness deviations within which no screw operation will occur can be preset in the regulator panel and is usually set at plus or minus 0.0005 in. thickness. Thickness leaving stand 1 is held within plus and minus 0.0007 in. although incoming strip may vary sometimes as much as 0.0070 in.



zero deviation. The a-c phase sensitive signal cannot be used directly in the control, so it is impressed upon a transistor discriminator which converts the phase sensitive a-c signal to a reversing d-c voltage proportional to thickness deviation. The transistor discriminator consists of four power type transistors connected in a bridge circuit and having phasing transformers so connected as to make the transistors operate as open and closed switches on alternate half cycles. The direction of current flow through the transistor switches when they are closed and depends upon the phase of the deviation signal with respect to the phasing transformer output. The reversing d-c voltage output of the transistor discriminator is applied to indicating and recording instruments, the error detecting circuit, and the on time circuit.

Error detector—The error detector consists of a pair of small magnetic amplifiers, the outputs of which control error up and error down relays. A rheostat under the control of the operator determines the minimum thickness deviation from desired thickness necessary to operate the relays. Magnetic amplifier bias adjustment not under the control of the operator is incorporated to set the proper operating points on the magnetic amplifiers.

On time circuit—The transistor discriminator output is also applied to a control field on another magnetic amplifier which controls the on time, or the length of time the screwdown motors will run during any regulating cycle. The on time circuit is shown on Figure 7 in simplified form. The on time magnetic regulator control field is energized from the transistor discriminator through a bridge rectifier so that either polarity output of the discriminator will produce an output voltage on the on time amplifier. The on time magnetic amplifier output voltage will depend only upon the magnitude of deviation signal output from the transistor discriminator. At the beginning of the on time cycle, a capacitor starts charging through a resistor connected to a d-c voltage bus. The increasing voltage across the capacitor is compared with the fixed voltage output of the on time magnetic amplifier. When the voltage across the capacitor exceeds the amplifier voltage, a current will flow from the capacitor to the magnetic amplifier through the rectifier and magnetic amplifier field. This current will then turn on the second magnetic amplifier and pick up a relay which stops the on timing and starts the off timing. If the magnitude of the thickness deviation is small, the capacitor output voltage will exceed the magnetic amplifier voltage in a very short time and the on timing cycle will be short. Conversely, if the thickness deviation signal is large, it will take considerably longer for the capacitor voltage to exceed the magnetic amplifier voltage and, therefore, the on timing cycle will be long. A rheostat, again under the control of the operator, will change the charging time of the capacitor depending upon how hard the material is. The harder the steel, the greater length of time the screwdown motors should operate to perform the proper correction of thickness.

Off time circuit—A change of thickness after an operation of the screwdown motors cannot be detected by the x-ray gage until the corrected piece of steel strip has been transported from the stand one work

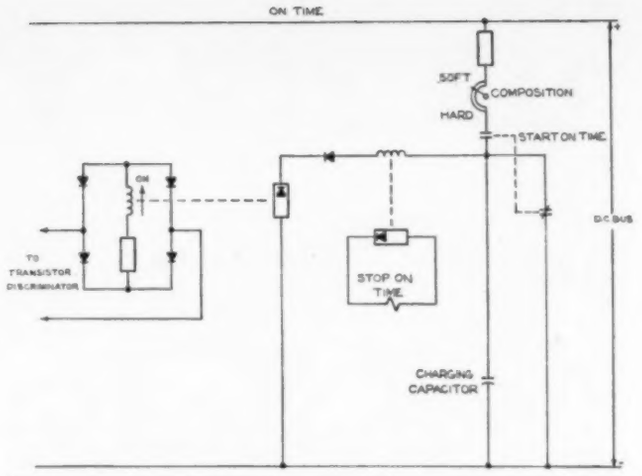


Figure 7 — Schematic shows on-time circuit.

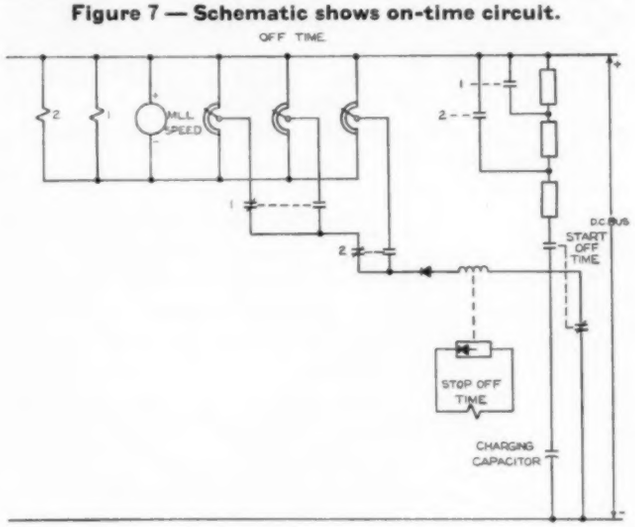


Figure 8 — Schematic shows off-time circuit.

rolls to the x-ray gage. This time which is called transport time is a function of mill speed. A plot of transport time versus mill speed would produce a hyperbola and, therefore, the off time circuit must also produce timing to approximately match this hyperbola. The circuit for doing this is shown in simplified form on Figure 8. Note that here again as in the on time circuit a capacitor is charged from a d-c bus. However, the voltage against which the capacitor voltage is matched consists of the d-c bus voltage minus a voltage produced by the mill tachometer which is a direct function of mill speed. When the capacitor voltage exceeds the set voltage of the bus minus the mill speed voltage, current will flow through the control field of a magnetic amplifier which in turn picks up the relay that stops the off timing and starts the on timing again. The hyperbolic curve which is desired is obtained by using three different charging rates on the capacitors and three separate percentages of the mill speed tachometer volts. The charging resistors and the tachometer volts are changed by means of relays connected across the mill tachometer voltage. Each relay is adjusted to pick up at a different mill speed. With this arrangement, an off timing is obtained that is not more than 5 per cent different than the desired hyperbola at any point. Magnetic amplifier bias circuits are again furnished to set the proper operating points.

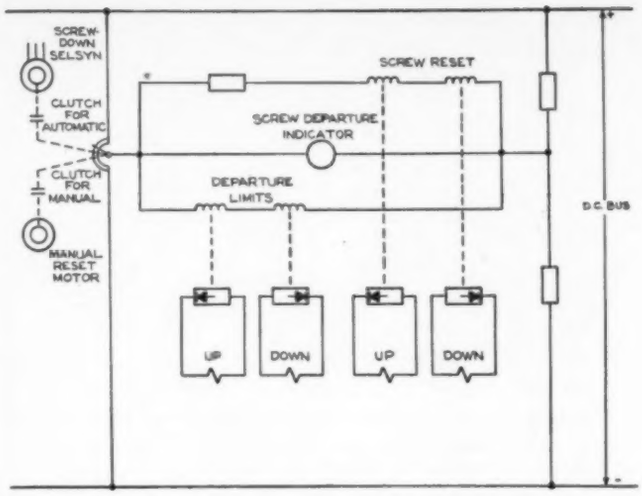
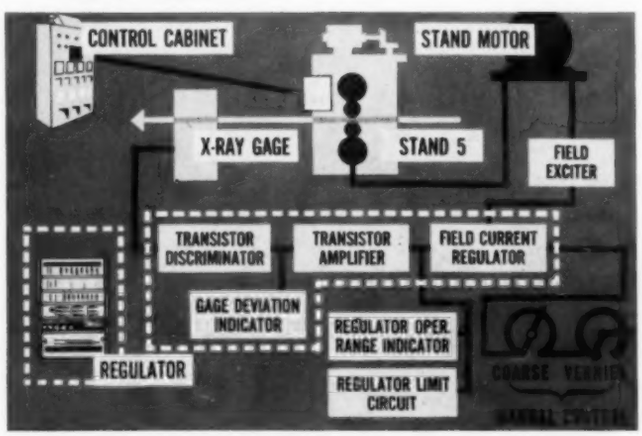


Figure 9 — Circuit shown controls screw departure, limits and reset.

AUXILIARY FUNCTIONS

Screw departure limits and reset—Since the head end of the cold reduced strip is normally heavier in thickness than the center section of the strip, it is desirable to have the work rolls spaced closer together at the beginning of the strip than they are at a later time, and for a production run of several coils it is desirable to start with the work rolls at the same spacing for the head of each coil. The screw reset circuit performs this function. A 40 turn helipot is connected through a magnetic clutch to a selsyn receiver, which is in turn electrically connected to a selsyn transmitter on the screw down of stand 1. The system is set up so that the mid-point of the helipot corresponds to zero departure. During automatic operation, the magnetic clutch between the selsyn receiver and the helipot is energized; therefore, during any movement of the screws, the helipot will turn in direct proportion to the amount of movement of the screws. The helipot is set up in a bridge circuit across the d-c bus as shown on Figure 9. The voltage that is obtained as the helipot moves from the mid position is used in three ways: (1) it is measured by a meter on the operator's control to give an indication of how far the screws have departed from a pre-selected point; (2) it is used to energize the control fields of two magnetic amplifiers which comprise the screws limit circuit to prevent the screws from opening the work rolls so far as to start slipping, or from closing so far as to overload the main drive motors; (3) it is used to energize the control windings of two other magnetic amplifiers which comprise the screw reset regulator. When the tail end of the strip passes out of stand 1, the reset regulator circuit is energized by the helipot error voltage and either the reset up or reset down relay is picked up by means of the amplifying magnetic amplifiers. These relays then cause the screws to run up or down as necessary to return the helipot to its mid position at which time the screws will stop and will be ready to accept the head end of the next strip. During the initial setup of the screws for the head end roll opening of a new order, the automatic thickness control is operated on manual operation. The selsyn motor is declutched from the helipot and a small reset motor is clutched to the helipot and in turn operates to return the helipot to its mid-position ready for the next automatic operation.

Figure 10 — Block diagram shows automatic thickness control vernier system. Although, the stand 5 motor speed is changed under regulator action, the automatic control includes a motor field current regulator. In future systems, where individual stand generators are employed, adjustment of motor speed will probably be obtained through adjustments of generator voltage regulators.



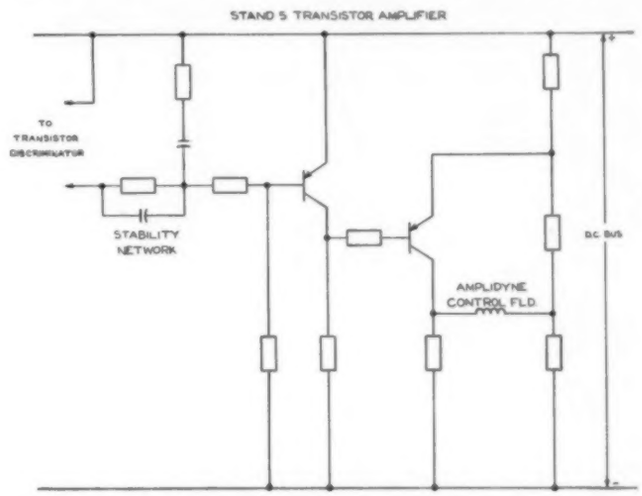


Figure 11 — A 2-stage transistor amplifier is interposed between the output of the discriminator and the rotating regulator.

Vernier regulator—The vernier regulator utilizes a 50-kv x-ray gage which again supplies a deviation error signal in the form of an a-c sensitive voltage the same as stand 1. Here again the selsyn deviation signal is applied to a transistor discriminator as shown on Figure 10. However, the output of the transistor discriminator is not of sufficient power to work directly into the rotating regulator control field of the stand 5 motor field regulator. Therefore, a two-stage transistor amplifier was interposed between the output of the discriminator and the rotating regulator fields. This is shown on Figure 11. The particular arrangement of transistor amplifier shown provides a reversing output so that the rotating regulator control field can swing the motor speed either plus or minus from its normal operating point. Since this regulator is a continuous type, an additional stability network was

added to the transistor amplifier section to prevent hunting under automatic control operation.

Since this regulator is essentially a vernier type regulator having limited range, a speed departure indicator is provided for the operator to indicate in what part of the available range of the regulator the control is operating. Indicating lights are also provided to warn the operator that the regulator is out of range, and other adjustments must be made to return the regulator to the proper range.

This equipment including both regulating circuits has now been in operation for ten months and much operating data has been accumulated during that time.

PART III — RESULTS

By R. W. HOLMAN

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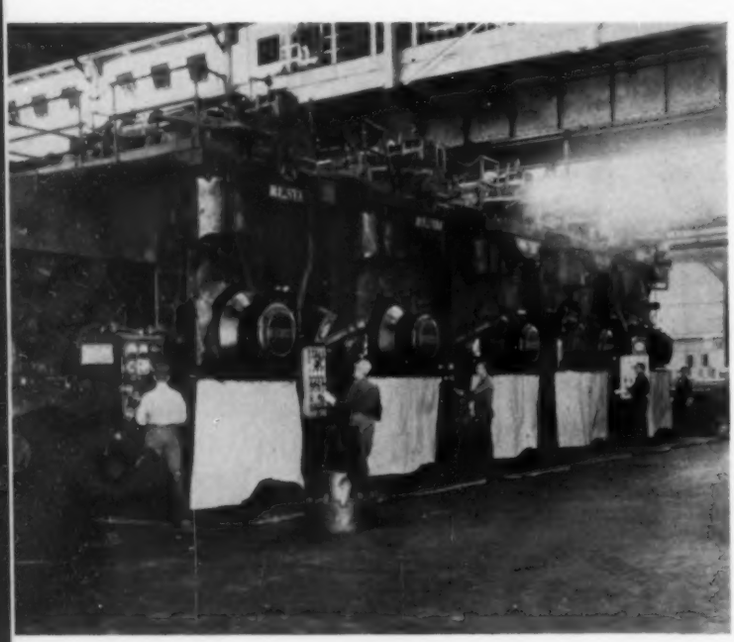
▲ IN this phase of our three-sided approach to presenting the thickness control story, the system shall be discussed from the user's point of view. U. S. Steel Research approached the supplier company with the idea that there was a definite need for automatic thickness control for tin plate mills, and found that they had been doing some planning along similar lines. With our interest expressed, they conducted more detailed studies and shortly proposed an equipment that looked promising.

At this point, we shall discuss why there was a need for this system. The five reasons are as follows:

1. The task of maintaining output thickness was a strictly manual task—and a monotonous one—requiring constant and continuous attention to thickness meters and controls.
2. The quality of tin plate, from a thickness standpoint, was subject to variations from shift to shift, due to personnel attitudes and changes, as well as incoming hot band variations.
3. Under manual controls, the pattern of hot band variations appeared in the finished tin plate, but to a somewhat lesser degree.
4. There were indications that our customers were interested in tighter thickness tolerances, and this was a means of studying the situation.
5. Tin plate is sold by area rather than by weight; consequently, the closer the plate can be produced to the ordered thickness, the greater are the yield savings that may be realized.

Figure 12 — Mill with control equipment is shown in operation.



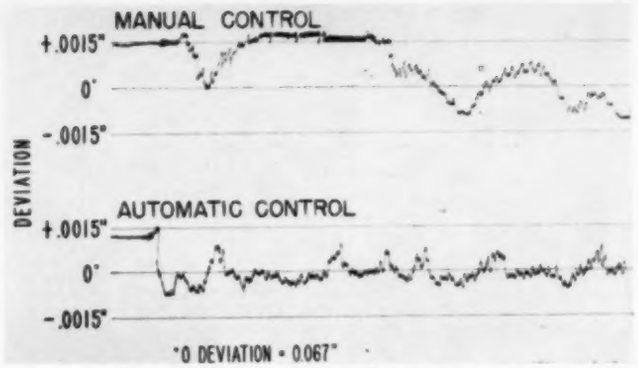


Figure 13 — Charts give a comparison of the thickness of 0.0115 x 36½ in. finished product obtained with manual and automatic control.

The manual task of cold reduction mill thickness control was a natural for automatic control since the sensing device—the x-ray gage—had been developed in the late 1940's. The persons on the mill controlling thickness watched meters and made adjustments accordingly—usually screws in the case of No. 1 stand, and motor speed in the case of No. 5 stand.

A similar instance of constant attention to product and rheostatic controls—the control of strip loops—was made automatic years ago with the modulated loop control. Although the cold mill job is more complex, the advent of analog computer techniques in

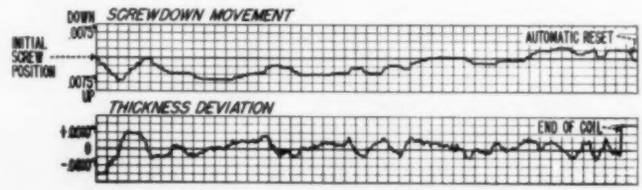


Figure 14 — Chart shows screwdown movement and thickness out of No. 1 stand.

designing feedback control systems brought this job within the realm of accomplishment.

The thickness control equipment was installed in April, 1955, and after a period of adjustment, has been in almost continuous use since that time. After this period of time, we may now look at the benefits available:

1. The "Roller" and "Sticker" are relieved of continuous attention to thickness meters.

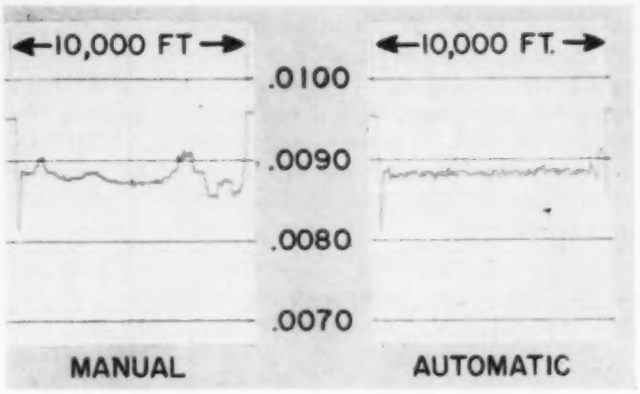


Figure 15 — Chart gives thickness out of No. 5 stand. Note better quality shown by chart on right which was taken with automatic control on both No. 1 and No. 5 stands.

2. The mill, on automatic, will produce uniformity of thickness in the range of 3-to-1 improvement over manual methods.
3. There are indications that the mill arrives at the on-gage point in a far more uniform manner on acceleration from coil to coil than on manual control.
4. The improved uniformity of thickness at the cold mill is conducive to improved operations in subsequent processing.

The facility where the thickness control equipment is installed is shown in Figure 12. Here one can see the No. 2 5-stand cold reduction mill at Irvin Works. It is a 48-in. wide, 4-high mill rated at a top speed of 3850 fpm. Its production is mainly tin plate, with some light-gage product for galvanizing. The light-colored control cabinets at stands No. 1 and No. 5 are the modified cabinets to accommodate the thickness controls, with the gage-setting selsyn indicators mounted above these cabinets. The delivery end x-ray gage head may be seen above the belt wrapper at the delivery end of the mill.

Figure 13 shows a comparison of product thickness between stands Nos. 1 and 2, with the top chart representing manual control and the bottom chart representing automatic control. This improved uniformity being supplied to the last four stands results in a more stable mill operation with the remaining stands maintaining their reductions within closer limits. The No. 1 stand control alone considerably reduces the frequency and amount of speed change necessary on the last stand to maintain thickness at specification.

Figure 14 is a two-channel chart showing thickness between stands Nos. 1 and 2 on the lower trace and movement of No. 1 stand screws on the upper trace. In this instance, the screws moved over a distance of 0.010 in. to maintain the strip thickness at approximately ±0.0007 in. They operated 55 times during this approximately 11,000-ft coil. Note the light head end; this displays the screwdown reset feature which may be used to automatically bring down the screws a preset distance at threading. This feature is designed to aid the crews in getting "on-gage" more quickly at head ends.

Figure 15, at the left, displays output thickness with the mill under manual control on No. 5 stand and automatic control on No. 1 stand. The right hand display is a coil on the same order with the mill under automatic control on No. 1 and 5 stands. Note the difference in uniformity. At least 3-to-1 improvement is exhibited here. With a complete mill on manual, the variations are greater than on the chart at the left.

Figure 16 is a representation of numerous coils with four examples of automatic control and three examples of manual control under the same conditions mentioned in Figure 15. The uniformity of the automatic control is accentuated here.

Figure 17 shows high speed charts during acceleration of the mill, with the top example showing No. 5 stand on manual and No. 1 stand on automatic. The bottom chart shows the conditions with both stands on automatic. Note that in the automatic example, the mill reaches commercial tolerance at 1540 fpm, while the manual reaches it at 2315 fpm.

The automatic example reaches aim gage 2½ seconds later, while the manual example reaches aim gage 15½ seconds later. A review of various charts indicates that the automatic system will faithfully repeat this performance if the operator feels the strip will take the tension necessary to get gage early in the acceleration cycle, and returns the vernier rheostat to the operating position as soon as acceleration starts. An alert operator on manual control can reach the on-gage point as quickly as with the automatic control; however, it is

Figure 16 — Charts compare finished thickness deviation on manual and automatic control.

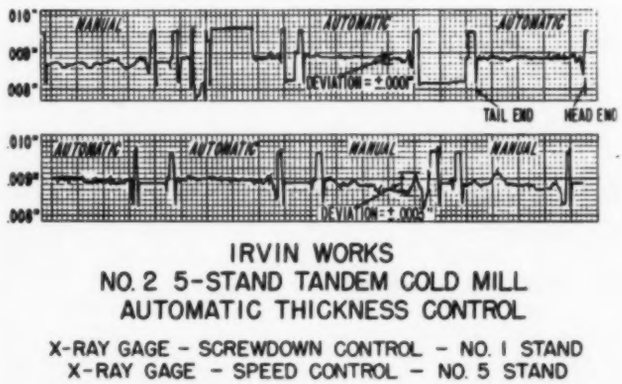
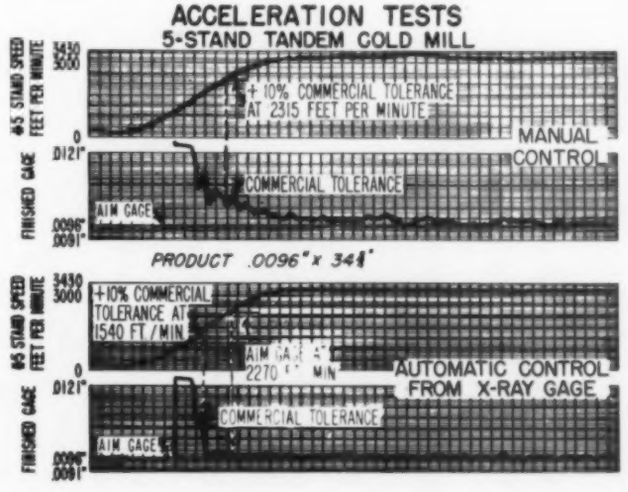


Figure 17 — Chart shows variation in thickness during acceleration of the mill.



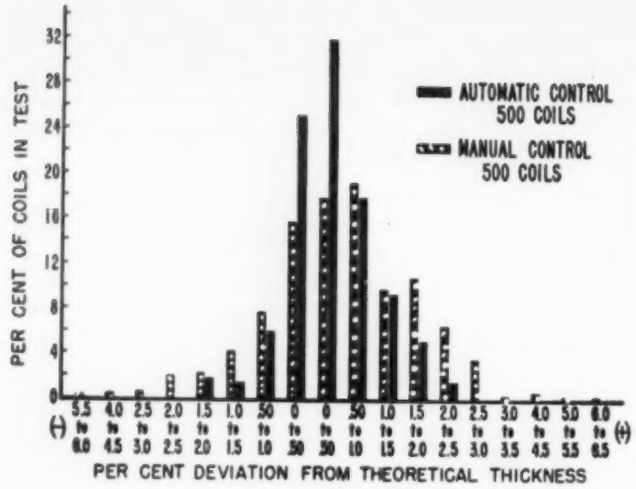


Figure 18 — Much more uniform thickness is indicated by the wrap test when automatic control is used.

reasoned that the required attention cannot be maintained on a continuing basis. A review of charts with the mill under manual control during acceleration indicates both better and poorer results than the one indicated.

Figure 18 is a graphic representation of wrap checks under automatic and manual control. The wrap check method of thickness testing is a production control test used as a rough check on the x-ray or contact gage. It consists of counting approximately 800 wraps and accurately measuring the distance between the first and the 800th wrap which were marked while the coil was rolled. This dimension is then applied to a prepared chart and an average thickness per wrap is read from the chart.

This bar graph shows that on automatic, approximately 21 per cent more coils are within the ±1 per cent band than on manual. The figures are 59.8 per cent on manual and 80.6 per cent on automatic within the ±1 per cent band. In addition, the outer limits have been reduced from −6.0, +6.5 per cent on manual to −2.0, +2.5 per cent on automatic control.

To summarize, it may be said that this development represents a marked advance in both the cold reduction and the electric control art. This equipment has proved the reliability and advantages of transistors in the design and operation of main drive controls, opening the way for future applications. In addition, the manual control of thickness on cold mills has been reduced to the barest minimum, and the monotonous job of manual thickness control has been improved. Quality from cold mills equipped with this or similar control systems will be more uniform and less subject to human variations than in past years.

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By ROBERT JORGENSEN
Assistant Chief Engineer
Buffalo Forge Co.
Buffalo, N. Y.

▲ THE steel producer has the same problems as any other user of fans, only more so. Essentially the main problem is to select the proper fan for the job intended. Steel mills, being what they are, there are a number of different fan applications. Some of the fans are subjected to very severe conditions such as continuous operation in hot dirty places, and so forth.

This paper will: (1) review some of the fundamentals underlying proper selection, (2) outline a number of the recent developments in fan design, and (3) analyze a few of the typical steel mill applications in light of both fundamentals and recent developments.

DISTINCTION BETWEEN FANS, BLOWERS AND COMPRESSORS

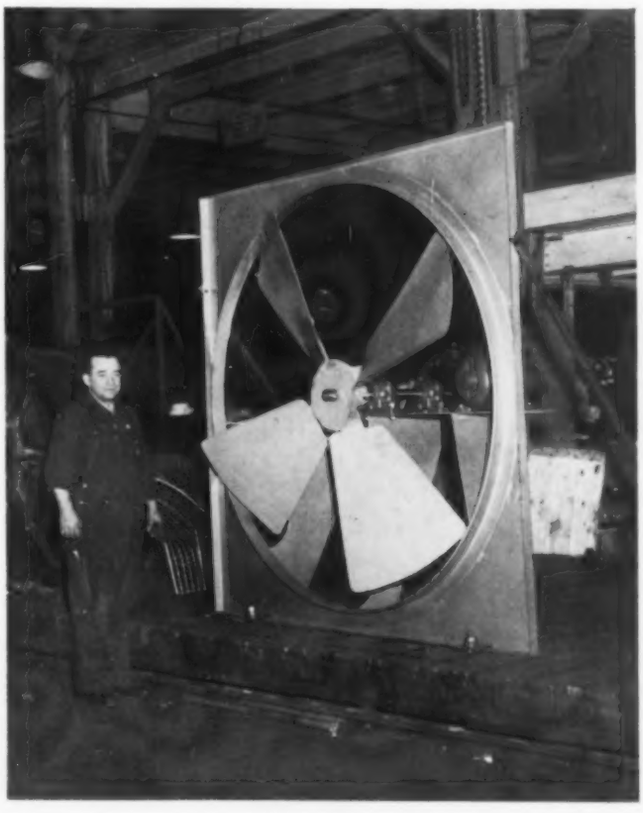
As a preliminary to selecting a fan, the user must first determine whether a fan, blower or compressor is indicated. Technically the dividing line is one of density change. According to ASME practice, fan codes apply below a 7 per cent density change while compressor codes apply for densities above that figure. In terms of pressure boost, this amounts to one psi or a head of 27.7 in. of water. Practically, however, fan manufacturers will build machines capable of pressure boosts of over 3 psi and two or more machines can be placed in series for even higher pressures. These machines will differ from blowers or compressors principally in that sheet metal tolerances rather than close-running machine tolerances will be used. Thus a relatively cheap fan can often do the job of a blower or compressor.

FAN TYPES AND APPLICATIONS

The basic purpose of a fan it to move air or gas from one end of a system to the other. To accomplish this the fan must impart sufficient energy to the air to overcome the friction and shock losses encountered by the gas in flowing through the system. This energy transfer is commonly accomplished in a fan by one or both of two distinct processes.

The first method involves increasing the velocity of the gas and subsequently converting that velocity into

Figure 1 — Heavy duty propeller fan shown uses 72-in. disk type wheel.



pressure head. This method is used in what are known as axial flow fans. Where flow rates are relatively large and pressures relatively low, one of the several variations of axial fans may prove to be the best choice.

The first variation, known as "propeller fans" are the simplest and most common type of fan used. A unit consists of a disk type wheel, which vaguely resembles an aircraft propeller, mounted in a ring or panel which in turn can be mounted in a wall. This is in fact what they were designed for: to blow into or out of a room. Large air volumes can be moved with a reasonable power expenditure and with a very small capital investment, since the fan is so simple. This type of fan is available in a wide range of sizes, both direct connected and V-belt driven. Direct-connected fans usually have the wheel mounted on the motor shaft. The shape and number of blades which the impeller has will vary between manufacturers and each manufacturer may offer various designs, some more rugged than others.

Precautions should be taken to insure that a propeller fan will not have to operate against more than the design static resistance. The flow rate may fall off and horsepower rise very rapidly at higher pressures.

Other variations of the axial flow types are known as "tubeaxial fans" and "vaneaxial fans". A tubeaxial fan may consist of either a disk type or an airfoil type impeller mounted in a cylindrical housing. If an airfoil wheel is used, it will probably have a relatively large hub. The tubeaxial fan is designed to be used in conjunction with a duct system where a pressure head is encountered. This means that some of the velocity head must be converted into static head. Since this conversion is quite inefficient in a tubeaxial, these fans are generally limited to low pressure applications.

Where higher heads are required, the vaneaxial fan (which has guide vanes either before or after an airfoil type impeller) is a better choice. The airfoil shaped blades provide for better flow through the wheel. Guide vanes make it possible to efficiently convert the tangential component of the velocity into usable static head.

Both tubeaxial and vaneaxial fans are made in various sizes for either V-belt or direct drive. Here, too, the shape and number of blades will vary between manufacturers, as will the ratios of hub to tip diameter. Quite frequently inlet and discharge cones will be used. Since axial fans are inherently high velocity machines it will often be advantageous to use ducts which are larger than the fan casing to keep duct velocities down. Where these fans are on the supply end of a system, they should always be used with a curved inlet bell to reduce entrance losses.

Propeller fans are used quite extensively for general ventilation duty in steel mills, but there are apparently very few applications for either tubeaxial or vaneaxial fans in the mill proper. In spot cooling where some duct run is involved, axials should be considered. Outside the mill, however, we find that mine ventilation is accomplished almost exclusively with vaneaxial fans. This is because the high volume, low pressure requirements are particularly suitable. The reverse flow feature possible with this type is also a contributing reason. In fabricating shops, a modified tubeaxial, known as a spray booth fan, is ideal where spray painting is used because it is specially built to facilitate removal of accumulated paint fumes.

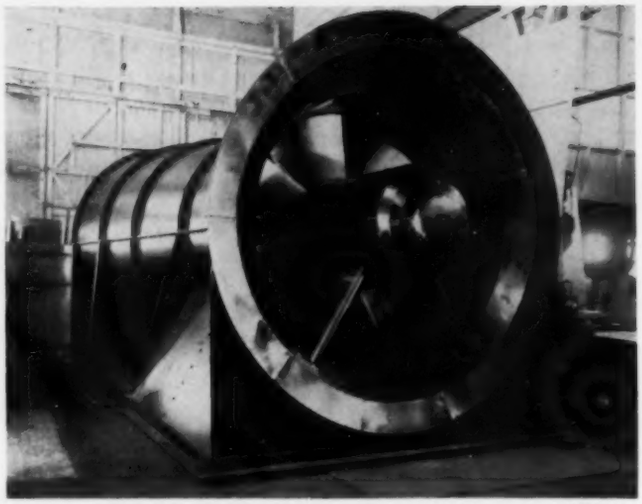


Figure 2 — Vaneaxial fan for mine ventilation uses 108-in. airfoil blade type impeller.

The second method of transfering energy to the air or gas in a fan is to utilize centrifugal force by rotating a column of air in a rotor built for that purpose. This, of course, leads to what is known as a "centrifugal fan." Actually, these fans simultaneously utilize centrifugal effect and increase in tangential velocity to produce a pressure head. The ratio of the two depends on the shape of the blade. Blade shapes are referred to as a backward-curve, forward-curve, straight radial, radial tip, double curve, backward inclined, etc. Regardless of blade shape, a scroll shaped housing is used to convert some of the velocity pressure into static pressure. The process of utilizing centrifugal force is inherently more efficient than the conversion of velocity. Since backward-curve fans depend more on centrifugal force than other types, better efficiencies can be realized with this type. Radial blades are relatively strong, which makes them particularly suitable for some applications, as will be seen below. Forward-curve blade fans are generally smaller for a given duty, which is their main advantage.

The efficiency of backward-curve blade fans can be improved by using airfoil sections in the blading. This is one of the more recent developments which will be discussed later.

Inlet guide vanes can be used with modified backward-curve blade fans to produce many of the same desireable characteristics such as limit load and stable pressure characteristics. In addition they have the advantage of stabilizing the flow entering the fan even if adverse conditions exist.

Generally speaking, besides the advantage of better efficiency, a backward-curve fan possesses more desirable pressure and horsepower characteristics. The horsepower characteristic is usually of the limit load or non-over-loading type. That is, if a fan is selected in the normal manner, regardless of what can happen in the system, the fan will not draw much more horsepower than at the point for which it was rated. The pressure characteristic is quite stable. That is to say, over almost the entire range the static pressure rises gradually with decreasing flow. This is important where sudden variations in flow may develop, since stable operation is assured.

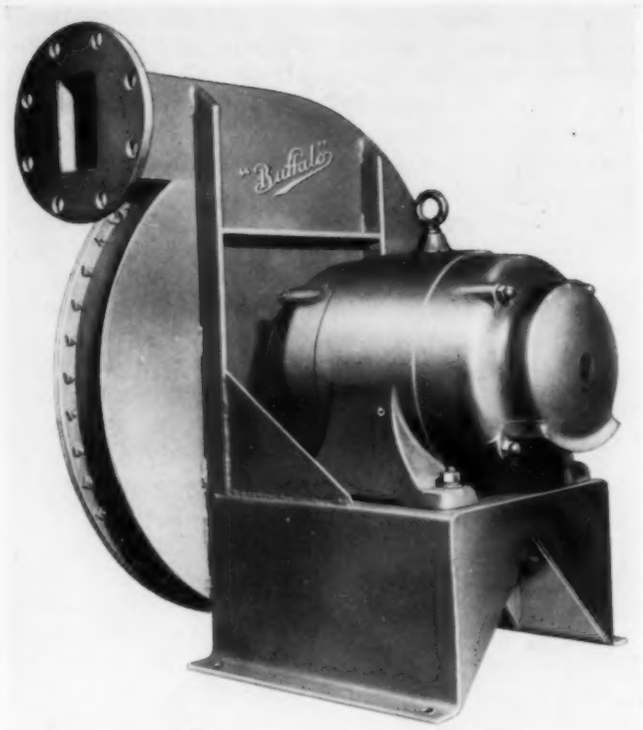


Figure 3 — Steel plate pressure blowers are usually used for pressures of 20-in. and above.

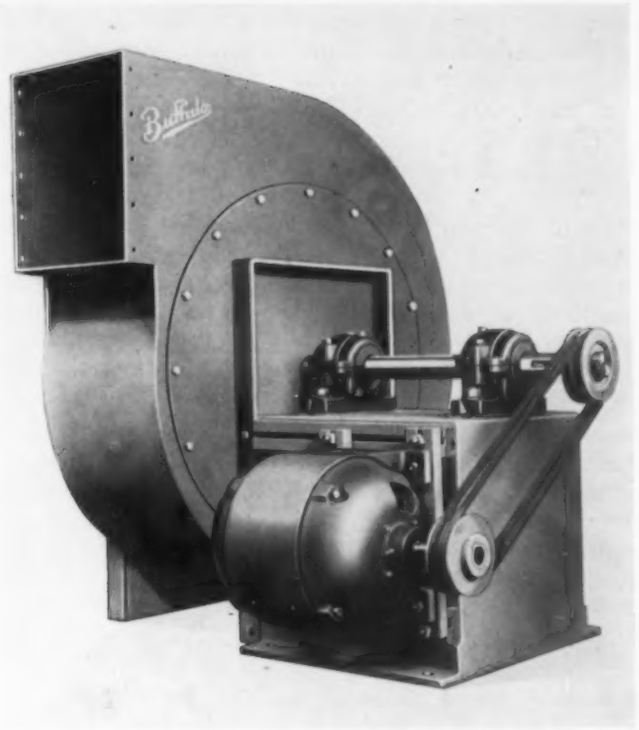


Figure 4 — Steel plate industrial exhausters are usually operated at pressures of 5 to 15 in.

The forward-curve blade fan is unstable over a large portion of its curve. It does not have a limit load horsepower characteristic. To take advantage of its space and cost savings, which result from smaller size, the system must be more rigidly controlled. Since for good efficiency the fan must operate close to the unstable range, precautions should be taken that the system resistance will not vary much from the design value. This is also necessary to avoid overloads on closely selected driving motors.

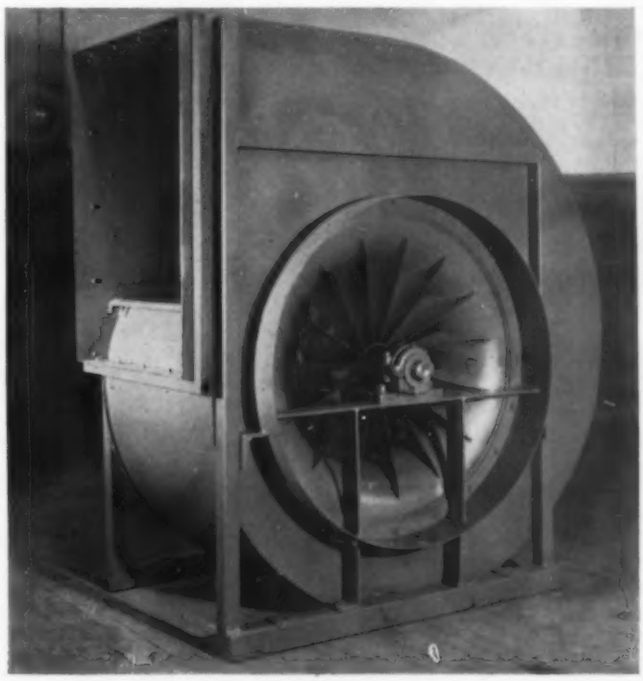
Centrifugal fans are also grouped in categories corresponding to a particular type of duty for which they may be intended. Pressure blowers, industrial exhausters and blowers, ventilating fans, and mechanical draft fans are the usual commercial designations for the various centrifugal fans.

Pressure blowers are used for pressure ratings of 20 in. water gage and above. They may be furnished with either cast iron or steel plate housings. The former is usually limited to the lower ratings and also definite increments of size because of the need for expensive patterns, etc. The latter may often be built to order for a specific job although numerous standard products are available. Straight radial blade type wheels are generally used. This type of blade has the ability to withstand the high centrifugal forces encountered in producing high pressures. The normal drive arrangement is to overhang the wheel directly on the motor shaft. These fans may also be equipped with their own shaft and bearings for either direct connection to motor or V-belt drive. Numerous special features, including packed, carbon ring, labyrinth or pressurized seals, special connections, special materials of construction, etc., are available. Two or more of these fans may be used in series to produce pressures in excess of three pounds per square inch.

Pressure blowers are not suitable for the high pressures required of blast furnace blowers, coke oven exhausters or compressors for bessemer converters. They are widely used as gas boosters in the coke plant and at the blast furnace.

Industrial exhausters are simply but ruggedly constructed fans suitable for a wide variety of applications. These fans usually operate at pressures of from 5 to 15 in. water gage and are also available in cast iron or steel plate housing construction. The former sometimes

Figure 5 — Centrifugal ventilating fan shown has backward-curve rotor and inlet guide vanes.



referred to as cast iron volume fans are usually limited to the smaller ratings. Both types may have any of a number of wheel designs. The straight radial blade is used most often because it is simple and can be made quite rugged. The number of blades may be reduced to as few as five or six with only a reasonable sacrifice in efficiency. A small number of heavy blades is often desirable because of the possibility of tramp material passing directly through the fan. This also allows for rugged construction at reasonable cost. Wheels of the paddle type, wherein the blades are mounted on a spider type hub are particularly suitable for high temperature, or for rubber covering. A similar type is known as a cone or open wheel, wherein the blades are mounted on a hub and backplate without an inlet shroud. This type is particularly suitable when stringy material may pass through the fan. Completely shrouded wheels having somewhat better efficiency are also available. Very often a manufacturer will make available a modified backward-curve wheel for the same line of housings.

Most of the applications of industrial exhausters may be described as local exhaust systems. Here, objectionable fumes, dusts or gases must be controlled in order to protect personnel or equipment. Typical examples include the wet, dirty vapors produced at the scarfing machine, the oily vapors given off at the reduction and tempering mills and the fumes developed at pickling tanks, tinning mills and galvanizing mills.

Rubber linings, plastic coatings, special paints and special materials are all used on industrial exhausters of one kind or another to provide protection against corrosion. In many cases standard steel or extra heavy construction of standard steel will give good service.

Ventilating fans may have either forward or backward-curve blade type wheels. Single inlet fans and double inlet fans (which are merely two single inlet wheels assembled in one large housing) are both used quite extensively. These fans are used over a very wide range of ratings covering a pressure range of from 1 to 7 in. water gage. Actually, since this is one of the most competitive items in the fan manufacturers array of equipment, quite detailed standards have been established. These standards cover wheel diameters, outlet areas, and classes of construction. Class I, for instance, covers all ratings up to a total pressure of 3¾ in. and Class II up to 6¾ in. Limits have also been established for Class III up to 12¼ in. and Class IV above that figure. These last two classes are actually somewhat out of the ventilating field and constitute a heavy duty line of fans.

Figure 6 — Extra heavy duty sintering fan is built with 1-in. thick steel housing and boxes.

While on the subject of standardization, there exists a group of standards covering rotation, fan outlet or discharge position, motor position and shaft and bearing arrangements which apply to all fan types. These are quite useful as all manufacturers use the same terms to describe similar apparatus. All these standards may be found in manufacturers or National Association of Fan Manufacturer's bulletins.

There are numerous places in a steel mill where ventilating fans may be found. Battery basement ventilation systems at the coke plant may utilize either centrifugal or axial ventilating fans. Other buildings such as the open hearth buildings may have ventilating systems incorporating these types of fans.

The large, slow speed motors used by the various rolling mills require ventilation to dissipate the heat of inefficiency and prevent dirt from contaminating the motors. Mill motor ventilation is a very important topic and has been covered recently in a paper delivered to this body.

Mill motor fans should be of the limit load type since resistance through electrical apparatus will vary and a non-overloading characteristic will prevent overloading of the fan motor. Heavy construction is particularly desirable for long life and minimum maintenance. General practice indicates that the NAFM standards on classes are not used. Instead Class I may be used up to 1 in. static pressure only, and Class II up to 4 or 5 in. only. All except the very large low speed units are direct-connected through gear-type couplings. Most fans are supplied in arrangement 7 which means that a subbase is provided for the direct-connected motor and that the wheel is supported on the shaft between two bearings.

The above remarks were based on mill motor ventilation practice. Most of the other systems requiring ventilation in a steel mill should be designed with the same ideas in mind.

Mechanical draft fans have been furnished in practically all of the various blade types. These applications are similar in requirements to ventilating applications, and hence the basic design of many ventilating fans is utilized in mechanical draft fans. However, since mechanical draft involves much more rugged duty, the fans are usually built accordingly. Forced draft fans will look very much like ventilating fans except that the various components such as wheels, shafts, bearings, etc., will be much heavier. Induced draft fans always require and forced draft fans sometimes require inlet connections. Since many double inlet fans are used, it has become normal practice to supply inlet boxes with the fans in order to facilitate such inlet connections and yet keep bearings out of the gas stream. This is particularly necessary where

the gas may be either dirty or at relatively high temperatures. Since solid or particulate matter may be included with the products of combustion, wear or erosion may be quite a problem on these fans. The common procedure to combat wear is to build up the metal thickness at certain strategic locations where wear is most likely to occur. Wearing plates are used on the rotors and scroll liners in the housings. Incidentally, in spite of the vast amount of research which most fan companies and others have and are conducting, there is still no certain cure for wear, and no NAFM member will make any guarantee about wear or wear resistance.

Mechanical draft fans generally utilize sleeve bearings mounted on independent pedestals and soleplates, whereas ventilating fans generally use anti-friction bearings mounted directly on the housing. In the case of high temperature fans various schemes have been used to maintain reasonable operating temperatures in the bearings. Both air and water cooling as well as circulating oil systems are in use today. Of course, plain uncooled bearings are used where conditions permit.

Various control schemes are in use where variable load is involved. These include variable speed obtained by either turbine drive, hydraulic or magnetic couplings, or variable speed motors. Variable inlet vanes or vortex control is also an efficient means of obtaining volume control. The simplest and cheapest means is still an ordinary damper. However, the cost of a more complicated device may very often be defrayed by the savings in horsepower which may result from its use.

Some manufacturers have placed an arbitrary upper limit on the temperature for which they will build fans. Generally speaking, this limit is around 900 F and applications at higher temperatures are left to those who specialize in the high temperature field.

Mechanical draft fans are widely used in the steel industry. Waste heat boilers which use the gases from the open hearth generally have an induced draft fan and the general practice is to use a straight radial blade type with heavy wearing strips and scroll liners.

The open hearth fans and over-fire blowers used on open hearths are usually standard forced draft type fans. These fans are normally of the limit load type with standard construction features. Induced draft fans are sometimes used to discharge waste gases from the coke plant to atmosphere.

Sintering fans which are really extra heavy duty induced draft fans are used both at the blast furnace, and recently, at the mines. The flow and pressure requirements for these fans are usually quite high and gas temperatures are in the range from 250 to 300 F. Radial blade induced draft type fans are used almost exclusively. Very heavy wearing plates and scroll liners are invariably specified. Power requirements on the largest of this type of fan may range as high as 3000-hp.

RECENT DEVELOPMENTS

The most significant developments that have taken place in the fan industry in the last few years are those which result from new or improved manufacturing techniques. It is now possible to utilize many of the preferred streamlined shapes which were just as desirable years ago but economically out of the question.

The most publicized bit of streamlining is, of course, the centrifugal airfoil blade. Vaneaxial fans have been furnished with airfoil blades for years. Before the same shape could be incorporated in a centrifugal fan it was necessary to improve the inlet shroud and inlet cone from the straight line shapes to curved shapes. This was made possible by recent improvements in spinning and pressing techniques.

Naturally, better efficiency was the object of all such streamlining. A streamlined inlet bell allows the air to enter the wheel at minimum loss. A streamlined inlet shroud makes possible better flow through the rotor. Once these steps were taken it was natural that the airfoil blade be incorporated. Non-airfoil fans of the backward-curve type can be built with static efficiencies approaching 84 per cent and total efficiencies approaching 86 per cent. Airfoil blade fans can be built with static efficiencies approaching 88 per cent and total efficiencies approaching 92 per cent. The cost of the airfoil section can be justified on some large jobs. The fans must rate at the peak and the overall power level must be quite high.

Few, if any manufacturers have experience with airfoil fans carrying dirty gases. An airfoil fan must be pretty well backward-curve by nature to achieve these very high efficiencies. It is doubtful whether any of the mill applications now involving radial or nearly radial blade fans will ever utilize the airfoil type without drastic changes in the system. This does not mean, however, that improvements have not or will not be made on these other types of fans. Such improvements are under way but have not been publicized.

The solution to the problem of erosion is not in sight. Work will continue along these lines and it is hoped that steel mills themselves will cooperate whenever possible.

The use of high efficiency air cleaning apparatus is increasing. It is conceivable that even some of the dirtiest present day steel mill applications for fans may become simple, clean gas applications. Then even airfoil blade fans may be used on such rugged applications as sintering duty.

The power roof ventilator is not a recent development but is being more widely used. Both centrifugal and axial flow type wheels are available. Certain standards including test codes and curb sizes, etc., are being developed.

FAN FUNDAMENTALS

As stated in the beginning, the main problem for the fan user is to make sure he gets the proper fan for his job. It is hoped that the foregoing material has served to illustrate the way to determine the best type of fan. Numerous cases are mentioned where efficiency is usually sacrificed to some extent in order to incorporate certain construction features which will permit longer life and steadier service.

Once the proper type of fan is determined, establishing the proper size is the next step. Although a number of sizes can be built to do any job satisfactorily, there is always one best size for the job. Of

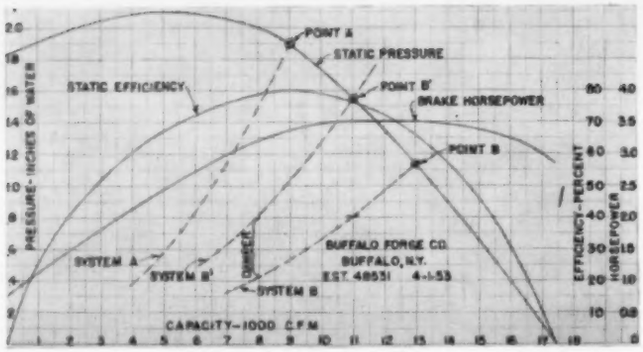


Figure 7 — Typical fan performance curves, typical system resistance curves, and effect of dampening is given for size 730, single inlet, 600 rpm, 0.075 density, 7.66 sq ft outlet unit.

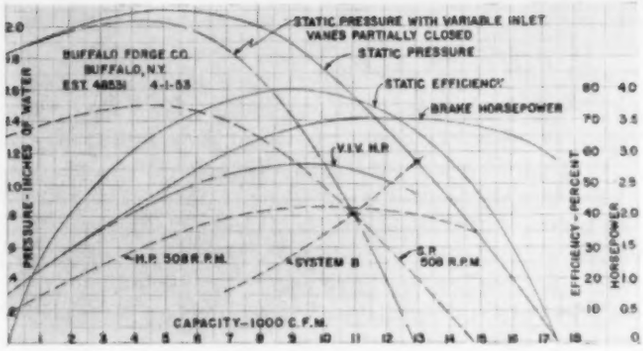


Figure 8 — Typical fan performance curves show effect of variable inlet vanes and variable speed for size 730, single inlet, 600 rpm, 0.075 density, 7.66 sq ft outlet fan.

course, it is desirable to rate as near the peak efficiency point as possible. Any fan which would rate to the left on the usual performance curve would be over-sized for the job. Any fan which would rate to the right would be under-sized. Both would require more horsepower than a full sized fan which would be rated at the peak. Where power is not evaluated too heavily, a slightly under-sized fan which does not require any larger motor than a full-sized fan, will certainly be the logical choice.

There are many methods, besides asking a manufacturer, that can be used to determine the best size fan of a given type for a job. The most popular method involves the use of a multirating table. Here the manufacturer compiles literally hundreds of ratings for each size. That is, the required speed and horsepower are given for a certain size for different increments of flow rate and pressure. Thus by comparing the ratings for several sizes the best size can be determined.

A fan performance curve similar to the one shown in Figure 7 is useful in understanding what to expect of a fan. The method of plotting this data as shown is the common one, that is, all other variables are plotted against cfm or flow rate. Note that the curve is drawn for a constant speed and a constant density of air or gas. The fan for which the performance curve is drawn will perform on any system, but only at a point which corresponds to some point on the pressure characteristic. That is, if the pressure for a given system varies with flow as shown by system resistance curve A, the fan will operate at the intersection point A. Similarly, the same fan will operate on system B at the intersection of its curve with the fan curve. A tabulation of the operating data for the two systems and fan shown would be as follows:

SYSTEM A	*SYSTEM B*
9,000 cfm	*13,000 cfm*
1.90-in. Static pressure	*1.13-in. Static pressure*
80 Per cent static efficiency	*66 Per cent static efficiency*
3.35 hp	*3.52 hp*
600 rpm	*600 rpm*
0.075 Density	*0.075 Density*

The normal range over which fans are rated lies between points A and B. Note that the efficiency is reasonably good and that operation will be stable since there is a constantly rising pressure characteristic. Note too, that in the case of a backward-curve fan, such as these curves are drawn for, the rated power will be reasonably close to the limit load horsepower.

When there is no dip in the pressure curve, there is only one intersection of the system curve with the fan curve. To make the fan and system operate at a different cfm, therefore, either the fan performance must be altered or a system resistance must be altered. This would have to be done in the event that this fan were installed on system B and it was desirable at times to reduce the flow rate. As explained before, volume control can be achieved most simply by means of some sort of damper. A partially closed damper in a system will increase the system resistance. This might be graphed as system B prime. Note that the system resistance is higher for any flow rate and that a new point of intersection with the fan curve is achieved.

The second alternative, that of altering the fan performance curve, can be accomplished with either variable inlet vanes or variable speed as shown in Figure 8. Note here that the system curve remains unchanged and that for different speeds or different positions of inlet vanes, a new fan performance curve results so that a new intersection of system curve and fan curve is possible. Observe also that there is considerable saving in horsepower when compared to the use of an ordinary damper. As explained before, only a complete economic analysis will enable one to determine which means of control is best justified. This is best done by the fan manufacturer provided he is given sufficient information as to the number of hours of operation at reduced capacity points and the dollar rate at which power will be evaluated.

Occasionally a fan user would like to make changes to a system which is in operation. If all that is desired is to increase or decrease the flow rate, and if the system resistance varies approximately as the square of the flow rate, the fan laws may be used to determine a new fan rating. These laws say that the capacity will vary directly with speed, the pressure will vary as the square of the speed, and the horsepower will vary as the cube of the speed. The fan laws are quite useful when small changes in flow are desired. However, it should be pointed out that when large increases in flow are involved, it will usually pay to investigate increasing the size of ductwork. In order to conserve on horsepower it is necessary to keep the resistance down.

If significant changes are made in the system, such as the addition of a piece of dust control apparatus, heater, etc., it is extremely important to remember that the fan laws *cannot* be used. Here one must re-rate the fan based on the new requirements of cfm and static pressure.

Another item which is sometimes confusing to the fan user is the effect of change in density brought about by either change in temperature or difference in barometer. If it is remembered that a fan is essentially a constant volume machine and that only the pressure it can develop and horsepower it will require are dependent upon the weight of the fluid, considerable difficulties can be avoided. Saying this in another way, the fan does not care whether it handles air or water, it will deliver so many cubic feet of either fluid per minute. The pressure which it will develop will be constant if expressed in feet of fluid flowing. The pressure, if expressed in psi or in. of water, will vary directly as the fluid density. Similarly, since the horsepower requirements may be expressed by the following formula, it can be seen that terrific horsepowers would be required if water, for instance, were handled instead of air, since the pressure would be $\frac{62.4}{0.075}$ times greater.

$$Hp = \frac{0.000157 \times \text{cfm} \times \text{static pressure (in in. of water)}}{\text{static efficiency}}$$

Summing up, the steel mill has many different fan applications, some of which are "nastier" than others. Quite frequently, for these "nasty" applications, efficiency has to be sacrificed to some extent. There is one best size for any given job and probably one best type. There is no substitute for experience in determining the latter. Fans are really very simple machines once the fundamentals are understood. It is hoped that this paper has given some insight into these fundamentals.

DISCUSSION

PRESENTED BY

IRWIN ROSENAK, Chief Engineer, Mill, Inland Steel Company, East Chicago, Ind.

E. S. SEELY, General Supervisor Fuel & Steam, United States Steel Corp., Gary Works, Gary, Ind.

ROBERT JORGENSEN, Assistant Chief Engineer, Buffalo Forge Co., Buffalo, N. Y.

Irwin Rosenak: As you stated, our problem in the steel mills is one of handling hot, dirty gases coupled with continuity of operation. The steel industry operates twenty-four hours a day, seven days a week, making continuity of primary importance. I was quite interested in your remarks concerning erosion because it is one of our principal fan problems.

Erosion is particularly troublesome in boiler draft fans and sintering plant fans. I might give you a few of the ways we at Inland have been trying to combat this problem of erosion in fans. We tend to use the flat blades rather than the backward or forward curve for various reasons. The blade is easier to clean. The blade is easier to replace. It is something that we can build in our own shops and replace with our own mechanics.

We use heavy sections both in the fan blade, the spider, and all portions of the fan. The flat blade is better adapted for using heavier sections.

We prefer to use steel hubs rather than cast iron hubs because of their greater strength, and steel hubs allow us to weld onto the hub for maintenance reasons. Of particular interest might be our use in fan blades of our Inland Steel four-way floor plate. We have found that the use of the four-way floor plate has greatly increased the life of fan blades. This is not particularly due to the analysis of the steel. Although the higher carbon steels will last longer, we have found that the surface shape of the floor plate allows greater blade life. The passage of the gases across the surface of the steel lugs tends to whip the abrasive matter away from the body of the blade, and the wear occurs on the lugs rather than scoring the plate.

All who have operated fans are acquainted with the fact that blade erosion is grooved. One particular spot on the blade, depending upon the type of fan, is always wearing out.

We have built extra heavy sections into those wear spots on troublesome fans. When replacing a blade, we will weld an extra bar in that spot, prolonging the life of the new blade.

Another problem which we have had with fans is that of balancing. Those who have operated large fans that handle hot, dirty gases have all experienced trouble with balancing. The traditional methods of balancing fans are rather crude. We of the operating end of the business would like to know whether you as the manufacturers have done anything for us to make balancing any simpler, or whether you have anything new to offer in the way of balancing a fan.

E. S. Seely: In my opinion, one of the "nasty" problems for the engineer or operator is to properly specify the fan capacity.

The fan manufacturer rates his fan on ideal inlet conditions which are often impossible to obtain due to the "shoe-horn" conditions that exist where the fan must be placed.

The boiler manufacturer predicts a draft loss based on 15 per cent excess air and a relatively clean boiler. Unless one is blessed with a perfect sootblower system, the draft loss will increase. The predicted flue gas weight to be handled by the induced draft fan is based on normal operating conditions and does not necessarily include the additional gases that must be handled during periods of peak firing.

In order to provide sufficient capacity, so that the fan will not be the bottleneck in the system, some boiler manufacturers recommend that several safety factors be applied when determining the fan capacity, namely:

1. Add 0.5 in. to the predicted draft loss.
2. Add 25 F to the predicted final flue gas temperature.
3. Increase the predicted flue gas weight by 15 per cent.
4. Increase the static suction by 30 per cent.

I would appreciate hearing any comments that the

author would care to make on safety factors to be considered when determining fan capacities.

Robert Jorgensen: As Mr. Rosenak remarked, it is common practice throughout the steel industry to specify radial blades, heavy sections and steel hubs for sintering plant and waste heat boiler fans. Experienced fan manufacturers agree that these applications require the utmost in rugged construction. There are, however, many mechanical draft fans on somewhat less severe duty in steel plants which may utilize more efficient blade shapes. The use of floor plate material with raised lugs is quite common. Beads of weld can also be used to cause the abrasive particles to skip and jump thereby reducing wear. While it is generally true that erosion will take place at one particular location on the blades of a given fan, it is equally true that this location may vary for different applications, even though the same type and size of fan may be involved. Wearing plates, when supplied as original equipment, are usually distributed over a fairly wide area, generally at the side furthest from the inlet. When a pattern of wear develops, most maintenance men prefer to build up the material near the area most affected.

The traditional method of fan balancing is a method of trial and error wherein the rotating shaft is chalked in order to determine the high spots and trial weights are added until balance is achieved. Most of the fan manufacturer's service men rely on this method since, through experience, they have acquired the skill necessary to obtain a rapid balance. An engineer would probably prefer the very fine new portable electronic equipment which can be used to solve for both location and amount of unbalance. Serious consideration should be given by the mill to employing the services of a fan man to train the maintenance crew charged with keeping the fans running.

Mr. Seely has raised two very important questions concerning fan performance. For one thing field conditions practically always differ from laboratory conditions. If a fan is squeezed into a system very close to an elbow, fan performance itself may suffer or else the loss through the elbow may be higher than calculated or both. Utilization of turning vanes or splitters can very often reduce the effect to the point where it is no longer detrimental. Most fan manufacturers welcome the opportunity to go over layouts before their fans are installed. It should also be noted that the standard fan test codes list various arrangements in which a fan may be tested. These include tests with outlet duct only, inlet duct only or both as well as tests with inlet boxes. It often pays to specify which test set up should be used as the basis for performance guarantees.

The method of increasing predicted gas temperatures, flow rates and resistance pressures is common practice for boiler manufacturers. Percentages of the order of magnitude given by Mr. Seely will generally provide sufficient margin to take care of increased leakage, increased resistance due to fouling and increased flow as well as the extra requirements for operation above design peak conditions. It is important to remember that excessive safety factors are to be avoided, not only because they will necessitate an over size fan and connected horsepower, but because under near normal conditions the point of operation may fall on an undesirable part of the curve. This is especially important on forward curve blade fans which might be forced to operate in the unstable region to the left of the peak pressure point.

FIRST AISE MERIT SCHOLARSHIP AWARDED TO OHIO MAN

▲ THE first Association of Iron and Steel Engineers Merit Scholarship has been awarded to Ralph D. Gray, Jr., of Killbuck, Ohio. He has elected to study chemical engineering at Case Institute of Technology in Cleveland, Ohio.

Mr. Gray was born in Akron, Ohio, in 1938 and attended the Killbuck public schools, where he was active in athletics, dramatics and music. An outstanding student, he was valedictorian of his class. He is the son of Ralph D. Gray, an employee of Republic Steel Corporation at Massillon, Ohio.

The scholarship, which will cover four years of study, is the first in a new educational project sponsored by the Association of Iron and Steel Engineers. The plan calls for a similar scholarship to be awarded each year to an outstanding boy who desires to study engineering. The plan is being administered by National Merit Scholarship Corporation, Evanston, Ill.

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AUTOMATIC PROCESSING ADDS TO STEEL PLANT LUBRICATION PROBLEMS

By S. J. BARBER
Manager, Metalworking Dept.
E. F. Houghton & Co.
Philadelphia, Pa.

▲ INCREASING automation in today's steel mill operation has intensified the problem of lubricating under high heat conditions.

Oven doors, rollers and conveyors all require lubrication. Carriers conveying products in process must be properly oiled to prevent freezing of the bearings. Straight petroleum oils will not adequately meet all the requirements, since they are limited as to their use under heat by their natural characteristics.

Realizing the increasing importance of proper lubrication in hot spots, Houghton Research has concentrated on the perfection of synthetic base lubricants that will withstand high temperature and on the selection of hydrocarbon oils having flash points well above 500 F. That mark is higher than was regarded as possible to reach only a few years ago.

Through years of continuous study and research, many facts have been gathered that can be helpful in properly classifying and selecting specialized lubricants for steel mill needs. Findings cover the general characteristics and requirements for high temperature oils, hot forging agents, fire resistant hydraulic fluids, and non-melting water resistant greases.

HIGH TEMPERATURE OILS

There are principally three main series of high temperature oils from which to choose. The oils in all three will provide dependable, clean and long term lubrication while preventing carbon build-up that would be likely to cause freezing or undue wear.

One group . . . which Houghton calls the 100 series consists of straight mineral oils with flash points up to 500 F. These are highly refined lubricants, with high flash and fire characteristics, and low carbon content. They are extremely stable when used within the recommended temperature range. Oils in this grouping leave a minimum of residue.

A second classification, the 200 series, includes semi-synthetic lubricants composed of oils of varying viscosities to which synthetic organic compounds have been added with the ability to lubricate at temperatures beyond that possible with straight mineral oils. Some oils in this series provide ample lubrication under intermittent high temperatures up to 600 F.

With these oils, the synthetic content provides adequate lubrication long after the hydrocarbon content burns off or oxidizes. The mineral oils used should be selected for minimum of carbon residue.

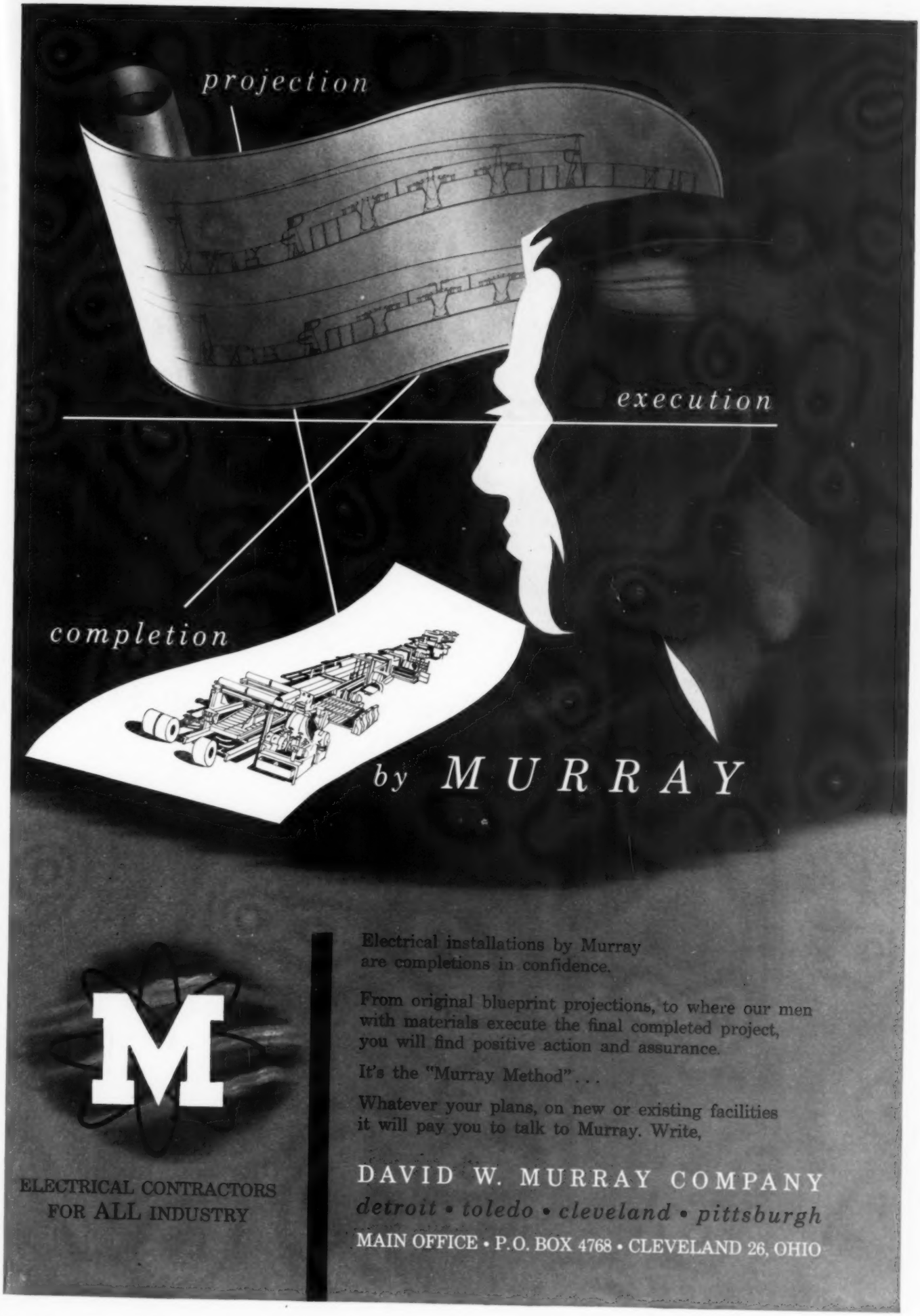
The third, or 300 series, includes various oils intended for service in temperatures above 500 F. These generally consist of colloidal solids in light volatile carrying oil. The latter vaporizes under high heat, leaving a film of solid lubricant to provide protection against wear.

One oil in this series, a colloidal graphited product, has been used at temperatures of as high as 1,000 F. Another newly developed high temperature oil, combining a synthetic high temperature fluid and molybdenum disulphide, offers the fluid advantages of the synthetic oil together with the load carrying capacity and high temperature characteristics of molybdenum disulphide.

HOT FORGING AGENTS

Punches, dies, rings and mandrels used in the hot forging of steel pro-

Figure 1 — Fire-resistant hydraulic fluid should be used in the tilting mechanism of electric furnaces.



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ANSWER:

Corhart 104 is different from other basic refractories because of its method of manufacture. It is made by electrically melting conventional raw materials at 4450° F., and then pouring this refractory liquid into pre-formed molds where it solidifies, forming a homogeneous, interlocking crystalline refractory structure.

QUESTION:

What Advantages Are Available With CORHART 104?

ANSWER:

Corhart 104 offers the advantages of non-connecting porosity, interlocking structure and greater mechanical strength at operating temperatures. Its high density makes it more impermeable to gases and slags. Its absence of connecting porosity gives it a greater degree of corrosion resistance.

QUESTION:

When may we discuss possible use of CORHART 104 in your operation?

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ducts are subjected to tremendous heat and pressure. Without the aid of special heat resisting lubricants to form a tough protective film on working surfaces, the punches and dies would soon show wear. Sooner or later this would reflect itself in the sacrifice of steady, accurate production.

Hot forging lubricants should have all the properties necessary to conserve expensive dies. Their fundamental job is to eliminate cracking and spalling. For best results, a good hot forging lubricant should provide: (1) high lubricity, (2) anti-seizure properties, (3) prolonged punch and die life, (4) durability, and (5) ease of use.

When dies are properly lubricated, smooth and accurate parts can be made without danger of pitting, scratching or formation of gas pockets. Any of these flaws will add to the reject pile and increase the mill's operating expenses.

FIRE-RESISTANT HYDRAULIC FLUIDS

Although a hydraulic pressure medium may not be considered a lubricant, it must possess some lubricating properties to prevent undue wear of pump parts and hydraulic equipment. Research and experience with fire-resistant hydraulic fluids have determined that the best product is one which combines the lubricity and efficiency of a high grade hydraulic oil with the safety of a water base "snuffer type" fluid.

In considering a fire-resistant hydraulic fluid, look also for the following characteristics: a high viscosity index giving resistance to viscosity changes at extremes of temperature; resistance to freezing; high oxidation stability for longer life; harmless to packings, and non-toxicity, making it safe for workers to handle.

NON-MELTING GREASES

There are a number of vital application points in a steel mill that require a grease with high temperature and water resistance. Interest is being expressed on chemically thickened greases which have no melting points. These can be exposed to elevated temperatures without the usual softening and drippage experienced with ordinary greases.

Thermal lubrication with these greases is recommended for rolling mill stands, conveyors operated at elevated temperatures, for pumps handling hot liquids, for bearings where drippage cannot be permitted, etc. Such greases are easily dispensed through conventional greasing equipment, and will not separate in storage nor in heavy duty service.

Most of the greases in this family are extremely resistant to heat breakdown. But they should not be used continuously at temperatures above 400 F without replenishment. The one you use should be oxidation inhibited to prolong its useful life under severe conditions.

Huge Pipe Expander Features Welded Construction

By C. W. LYTTON, District Engineer, The Lincoln Electric Co., Pittsburgh, Pa.

▲BUILDING heavy-duty tube mill machinery, such as the 154-ft pipe expander with a rating of 300,000 lb pressure, (Figure 1), calls for a nice balance of design, materials and fabricating techniques. Because of the extreme length and enormous weight, it proved impractical to construct such a unit as a single machine, so it was broken down into segments and bolted together at the installation site.

Heavy steel plate weldments meet all demands of strength and stiffness; also, have many advantages over castings in point of cost and flexibility, particularly since no patterns are needed. However, in non-stressed elements, where there are a number of like pieces, steel castings are a logical choice.

This king-size expander is of the mechanical, as against the conventional hydraulic, type. A 75-ft ram, carrying a lubricated tool-steel expander plug at its end, is forced through the pipe for its full length, expanding the diameter by as much

Figure 1 — Diagonally across the center is a test setup on a 154-ft, 300,000-lb pipe expander unit, with the chain-driven ram section in the foreground, the expander section behind it.

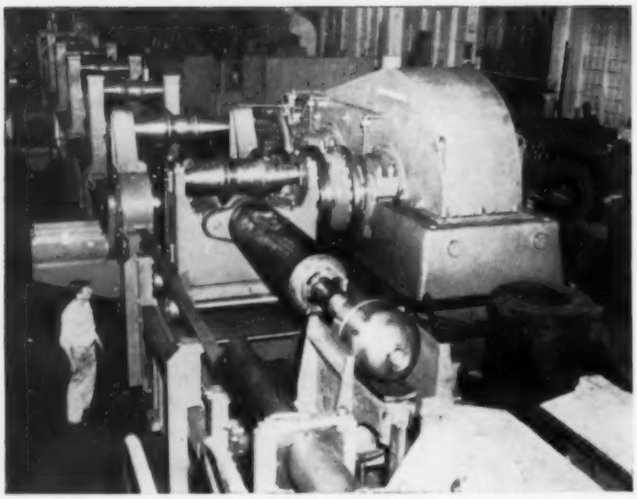
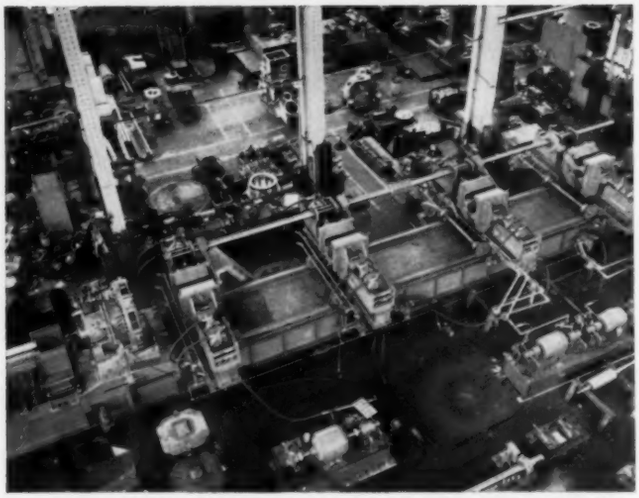


Figure 2 (left) — Looking down the ram half of the unit the expander plug is in the foreground and chain drive at the right. Figure 3 (right)]— Looking down on the "expander" half of the machine shows the backup sleeve at the left, four stands of hydraulic gripper blocks and a kick-up bar shaft which lifts the pipe out after expansion.



as 6 per cent. This work is on exceptionally heavy pipe sections, 16 to 26 in. diam with ¼ to ½-in. wall and up to 75 ft long. To cold work and "iron" seamless pipe to this degree, obviously, requires tremendous pressures, along with adequate holding mechanisms and supporting structure that can absorb the high tensile, bending and shear stresses.

The pusher or ram is powered by two heavy endless chains, riding over pairs of sprockets at either end of the 75-ft "ram section" of the machine. The forward sprocket is driven by motor and gear reducer, giving chain speeds of 110 to 135 fpm.

The pipe is held in four stands of split bearings or "grippers" positioned along the 75-ft "expander section" of the machine. The forward end of the pipe butts against a solidly anchored sleeve for further support against the pressure of the ram.

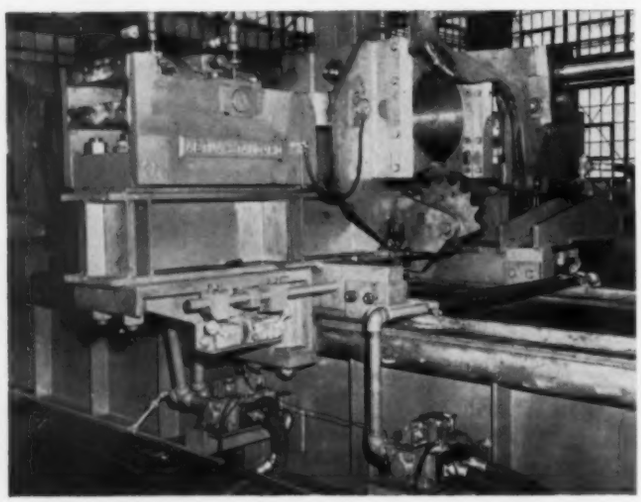
Each set of grippers is backed up by a pair of hydraulic cylinders, so arranged that sufficient pressure is developed to hold the pipe, along with enough resilience to accommodate the expansion of the diameter. Gripper blocks may be changed quickly to handle different sizes of pipe. They are retracted quickly to permit removal of a finished pipe length. This is done by kick-out legs on a common shaft extending the length of the expander section.

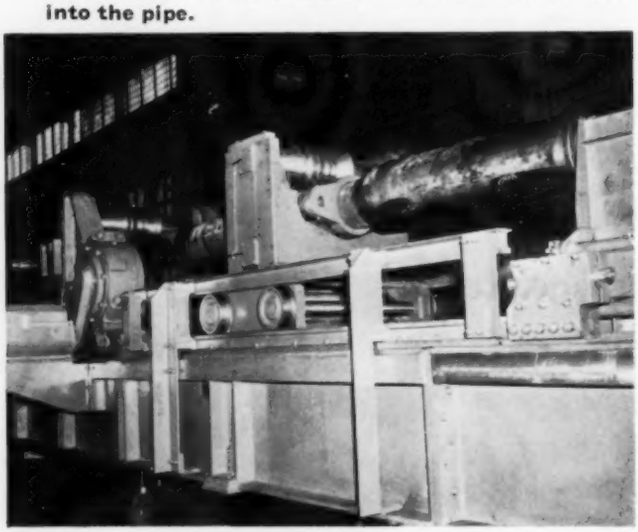
When Aetna-Standard Engineering Co., Pittsburgh, Pa., undertook the fabrication of this giant machine, a careful review was made of all possible fabrication and assembly techniques. It was decided to make the fullest use possible of arc welding because of its recognized flexibility and economy.

The machine base, for example, comprises multiple sections built up of 36-in. I-beams on either side, reinforced by welded web stiffener plates and inner transverse plates for tieing the two beams together. These sections are joined by heavy bolts and form a continuous rigid base for the full 154-foot length. A cover plate is welded across the top, and rails are welded to the top flanges of the beams to carry the gripper units on the expander section and the six cast steel, guide roll support frames on the ram end.

Figure 1-5, taken while the machine was under test at the builder's plant, give an idea of the unusual size of the equipment, and also show a number of typical welded joints in the base and superstructures.

Figure 4 (left) — One of the gripper stations (rear unit) shows the heavy welded plate construction. Kick-up leg may be seen in the raised position just ahead of the hydraulically actuated split gripper blocks. Figure 5 (right) — Base sections comprise two 36-in I-beams, reinforced by stiffener plates welded to the web and flange, along with internal transverse tieplates. This is the center of the machine, where the ram advances into the pipe.





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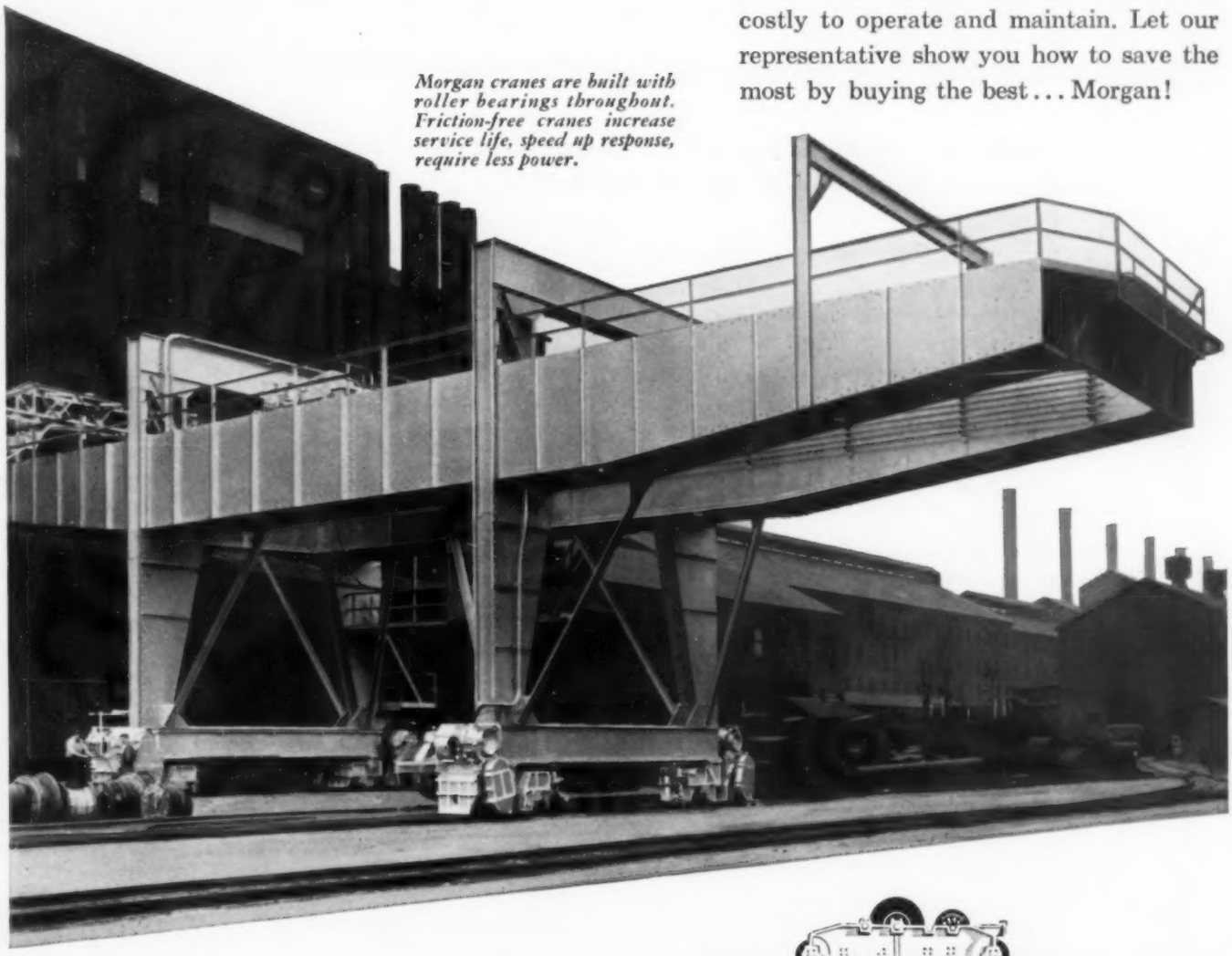

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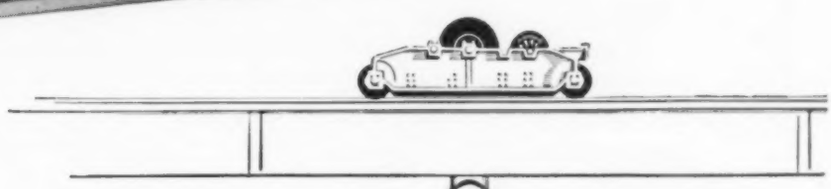

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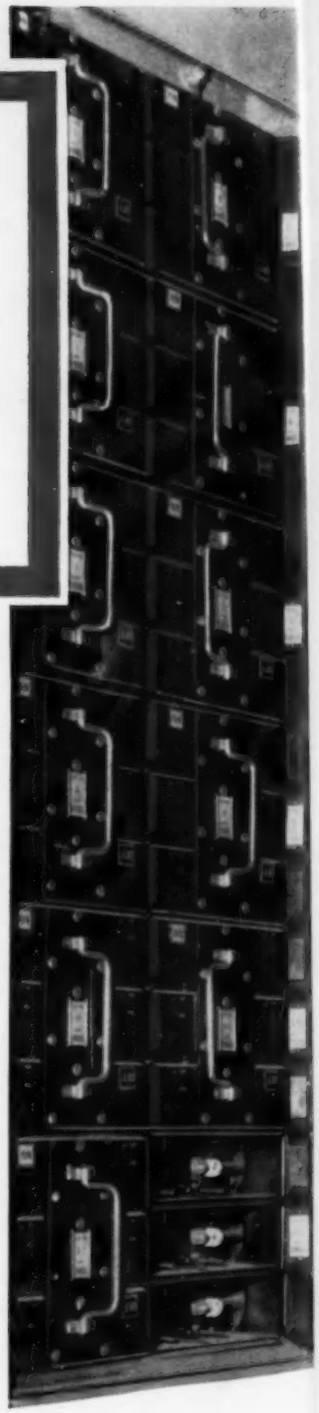

"SOLENOIDS WERE BURNING UP AND STARTING *FIRES* — *Until we changed to FUSETRON FUSES.*"

"A fire in our weaving room is just about the gravest danger we can face. If the fire isn't checked immediately, it can quickly spread throughout the room.

"You can imagine then how concerned we were with fires started by solenoids burning up in heavy lint locations. With 500 looms in use in 3 weaving rooms, we didn't know where to expect the next fire.

1

"We definitely had to find safer solenoid protection than we were getting from one-time ordinary fuses in use. We decided to try Fusetron dual-element fuses and installed them in the summer of 1954.

"It was a big relief when Fusetron fuses turned out to be the answer. I'll knock on wood, but we haven't had a fire since we installed them.

"In addition, this move to Fusetron fuses also cut production costs. We eliminated needless down-periods and we no longer have to repair or replace burned-out solenoids."

"WE CUT UNNECESSARY DOWN-TIME AND MAINTENANCE *COSTS By installing FUSETRON FUSES.*"

"Several years ago we had a heating problem in our main panels that was causing ordinary renewable fuses to blow.

"These outages occurred several times weekly in each panel, so down-time costs were really adding up and costing our company money.

"Also, after each blow our maintenance men would spend time checking the circuit for trouble, only to find the outage was caused by excessive heating in the panel.

2

"We discussed the situation with a salesman and he showed us that Fusetron dual-element fuses were cooler operating and would eliminate our trouble.

"They sure did! The change to Fusetron fuses of proper size for safe protection was completed in 1953. We haven't had any unnecessary shut-downs since then.

"Our maintenance men sure like the change. Any outage today indicates trouble, and the men know they are not wasting time when they check the circuit.

"Because of this and other satisfactory experiences with Fusetron fuses, we individually protect all our motors with them as well as using them throughout the rest of the electrical system.

"I wish we had kept a record to show how much money we saved by equipping each motor with Fusetron fuses. I am reasonably certain that the difference in motor burnouts alone would represent considerable money."

J. W. Sanders
CHIEF ELECTRICIAN

You too, CAN REDUCE FIRE HAZARDS AND DOWN-PERIODS by installing FUSETRON FUSES!

They provide 10 Point Protection

1. High interrupting capacity—protect against heaviest short-circuits. Have proven on tests to open safely on circuits set to deliver in excess of 100,000 amperes.
2. Protect against needless blows caused by harmless overloads.
3. Protect against needless blows caused by excessive heating—lesser resistance results in cooler operation.
4. Provide thermal protection — for panels and switches against damage from heating due to poor contact.
5. Protect motors against burnout from overloads.
6. Protect motors against burnout due to single phasing.
7. Give DOUBLE burnout protection to large motors — without extra cost.
8. Make protection of small motors simple and inexpensive.
9. Protect against waste of space and money — permit use of proper size switches and panels.
10. Protect coils, transformers and solenoids against burnout.

Write for bulletin FIS.

FOR LOADS ABOVE 600 AND UP TO 5,000 AMPS., Use BUSS Hi-Cap Fuses . . .

They have an interrupting capacity sufficient to handle any fault current regardless of system growth.

They can be coordinated with Fusetron fuses on feeder and branch circuits to limit fault outages to circuit of origin.

Write for bulletin HCS.

Play Safe! Install FUSETRON dual-element Fuses and BUSS Hi-Cap Fuses throughout entire Electrical System!

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TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

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By JOHN P. STRANGE
Chief Physicist
Mine Safety Appliances Co.
Pittsburgh, Pa.

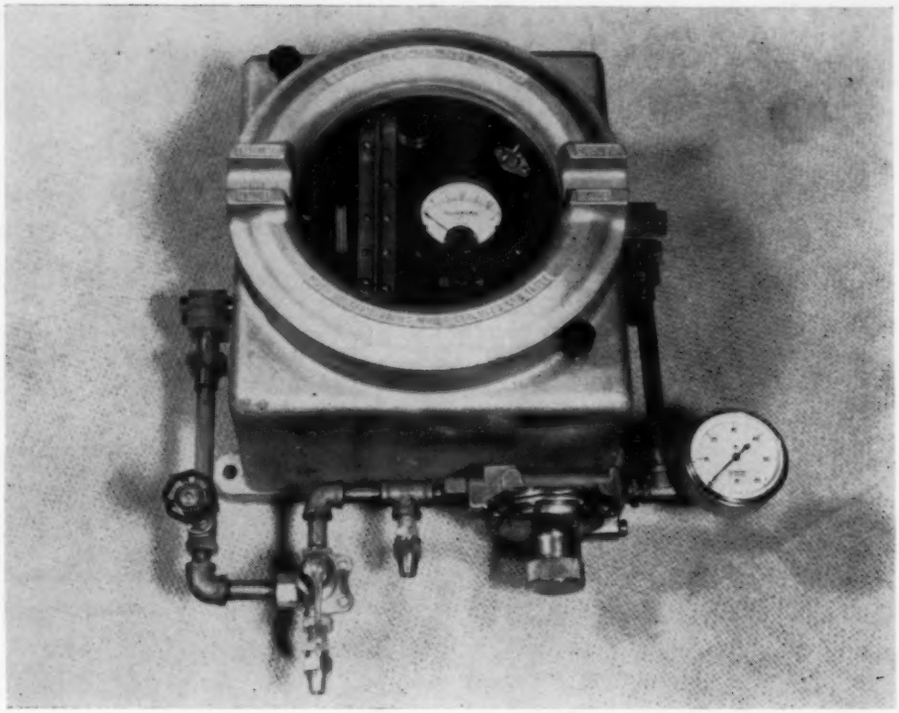

Figure 1 — The thermal conductivity analyzer in an explosion-proof conduulet housing for panel mounting is 10 x 10 x 8 in. in size.

Selective Measurement of Gas Concentration in a Multicomponent Mixture

▲ THE science of detecting and measuring the amount of certain gases in air or other atmospheres by observing their effect on the thermal conductivity of the gas mixture is quite old and very well covered in the literature. As early as 1840 Andrews[1]* discovered that electrically heated wires glowed more brightly in air than when surrounded by an atmosphere of hydrogen. In the early days of hydrogen filled ballons, instruments were devised to test the hangar atmospheres for dangerous accumulations of this very explosive gas. These instruments made use of the cooling effect of the gas on a heated wire which formed one arm of a Wheatstone bridge and the change in electrical resistance of the wire was correlated with the change in gas concentration.

However, it is not the purpose of this paper to review this old art but to describe some more recent work which has extended the usefulness of the thermal conductivity principle of gas detection.

It has long been recognized that an instrument which derives its signal from the change in the thermal-conductivity of the atmosphere being tested is not selective because of the great number of gas mixtures which can have the same conductivity. This did not prevent the successful application of the principle to the measurement of one constituent of binary mixtures or of mixtures whose other components always varied in a predetermined ratio. When these ideal conditions did not exist, it was sometimes helpful to remove an interfering compound by chemical scrubbing, or to maintain the effect of another constant as was done by saturating the tested gas sample with water vapor at a constant temperature. Such sample conditioning procedures introduce inaccuracies through the addition or removal of an unknown amount of the interfering component and are in general an inconvenience in that they require periodic service.

USE OF OTHER PHYSICAL PROPERTIES TO ACHIEVE SELECTIVITY

In applying thermal conductivity to the measurement of gas concentrations in the past, much emphasis has been placed on the need for minimizing the effects of heat loss from the sensitive element through other

*Numbers refer to Bibliography at end of paper.

Expert Salem-Brosius Engineering
SOLVED
This Tough Heat-Treating Problem

The complex battery of pit-type heat-treating furnaces shown above, drawn to scale and cut away to show the heating action, was designed and erected by Salem-Brosius. They are radiant-tube, gas-fired, forced-circulation furnaces designed to anneal and normalize helicopter propeller tubes and other tubular section in a nitrogen atmosphere.

The first two furnaces in the battery anneal at 1350°F both round and elliptical alloy steel tubes at the rate of 1200 lb per hr. The third furnace has an equal capacity, but normalizes the tubes at 1850°F. These furnaces will handle lengths from 3 to 15 ft and diameters from 6 to 18 in., with either uniform or varying wall thicknesses. Elliptical tubes may range up to 22 in. on the major axis by 10 in. on the minor axis. The equipment seen in the background includes a nitrogen gas generator and gas scrubbing, refrigerating and drying units.

We think you'll agree that in successfully solving this heat-treating problem, Salem-Brosius has the experience and know-how to solve yours. Write to us.

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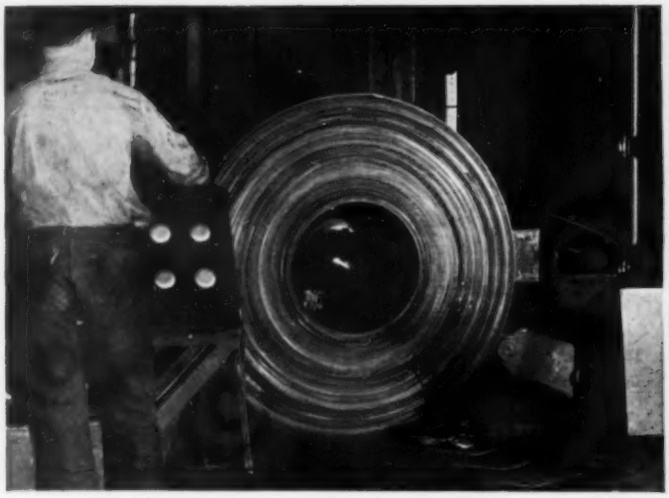
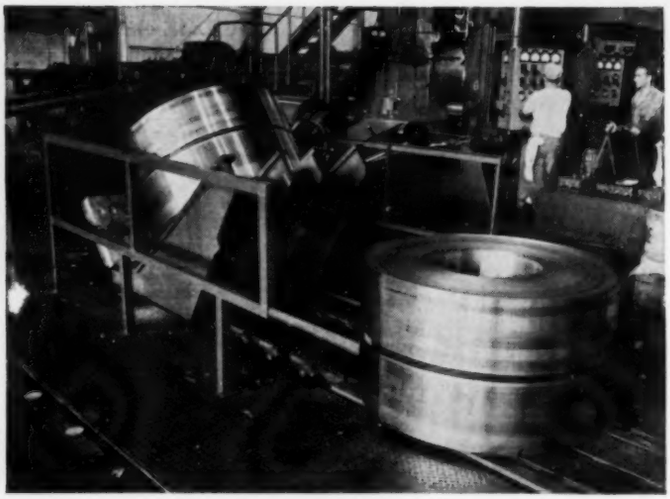


1 Link-Belt hydraulic lift raises coil at end of ride on cold mill entry conveyor. Then conveyor is reversed to separate this coil from others. Lowered into position, coil is discharged down a ramp by a hydraulic push-off arm, also supplied by Link-Belt.



2 From cold mill, coils roll down a ramp where they are stopped by a spring-loaded bumper. They come to rest on this Link-Belt downender which tilts and places them on the 40 ft. delivery conveyor. At end of trip, coils are removed by overhead crane.

3 Coils travel a 40 ft. conveyor to temper mill. Here a Link-Belt upender places coil on its side for pickup by overhead crane. Conveyor is reversible to give clearance for action of upender. Operator has "push-button" control of equipment.

Let Link-Belt coil conveyors lead you to

new yield and safety records

STUDY any mill that's setting production records. You're sure to find absence of waste . . . minimum physical labor and injuries . . . full utilization of capacity. To achieve all three, Alan Wood Steel Co. has Link-Belt coil conveyors installed at their Conshohocken, Pa. plant.

Their system consists of a pallet-top and two double-strand, flat-top roller chain conveyors, all durably designed to provide a steady flow of cold rolled strip. Reversible cold mill and temper mill entry conveyors allow coils to travel close together, assuring ample live storage capacity.

In steel mills all over the country, Link-Belt conveyors handle everything from raw materials to finished products with similar efficiency and economy. It will pay you to call in Link-Belt whether you're modernizing or building a new mill. Link-Belt specialists—working with your own engineers, consultants and builders of mill and process equipment—can help you select the right conveying system for your exact needs.

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than the conduction by molecular transfer. Hence the gas sample was made to enter the sample cell by diffusion, the clearance between the sensitive element and the cell walls was kept small to keep convection to a minimum, and the sensitive element was operated well below red heat so that radiation losses would be negligible.

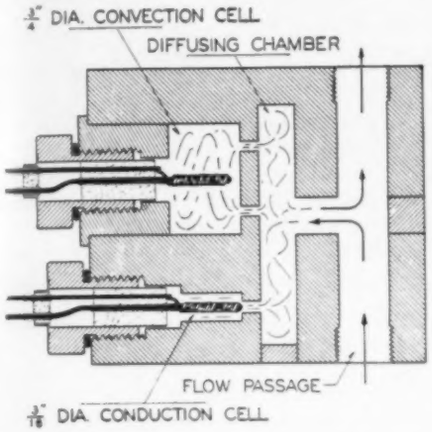

Figure 2 — The convection cell is relatively large compared with the conduction cell in the cell block.

In 1951 Clarke Minter and Lyle Burdy, then of the Naval Research Laboratory, described a modification of the usual thermal-conductivity instrument[2] which employed the convective heat loss together with that of conduction to improve specificity of the method. Instead of the usual two element detector cell which compares the heat loss from two identical filaments, one in the tested gas sample and the other in a reference atmosphere, four cells were used. The additional two cells were made large in diameter to promote convective heat loss from the filaments. The tested sample was compared to the reference gas, therefore, not only with respect to thermal conductivity but with respect to the other physical properties influencing heat loss by convection.

The filaments of the four cells were connected in the four arms of a Wheatstone bridge. The sensitivity of the bridge arms was adjusted empirically so that the effect of the gas to be measured on the bridge was maximized. It was then possible to analyze for one gas in a ternary mixture, i.e., hydrogen in the presence of CO_2 and air, while tolerating variations in the percentages of the other two constituents. Under a license agreement with Minter this technique has been further developed in the laboratories of Mine Safety Appliances Co. by R. C. Hollobaugh and G. C. Flumerfelt to make it applicable to a variety of gas analysis problems. Figure 1 illustrates one of these instruments.

The way in which selectivity for one gas was achieved can be shown by reference to the illustrations. Figure 2 is a cross section of a cell block similar to that described by Minter and Burdy showing the relative size of the large and small cells. Figure 3 shows the circuit with the filaments in a simple Wheatstone bridge.

MAKING THE BRIDGE SELECTIVE FOR ONE GAS

The rate of heat loss (H) from a cylindrical element in a cylindrical cell is influenced by the physical properties of the gas in the cell.[3]

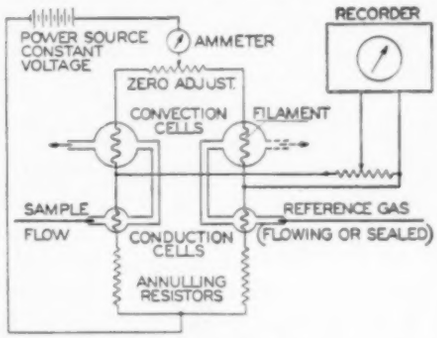

Figure 3 — Filaments of the four cells are connected in the four arms of a Wheatstone bridge.

In other words:

H depends on the expression

$$AK\left(\frac{cd^2}{VK}\right)^n + BK(T_2\text{-}T_1) + C$$

where H = rate of heat loss

K = Thermal conductivity of the gas mixture

c = Specific heat of gas at constant pressure

d = density

V = viscosity

A and B are constants depending on the cell dimensions

n is a cell shape factor

C is a constant including radiation and end loss to the filament supports

T_2-T_1 is temperature difference

The first term is the contribution of convention, the second term that of conduction. These terms show the relative effects of the various physical properties. The end loss and radiation are substantially constant under the conditions of operation. The constants and exponent "n" depend upon the cell dimensions.

To make the instrument specific for one gas in a multi-component mixture therefore, the equation can be used as a guide in enhancing the effects of that gas on one arm of the bridge while maintaining equal the effects of the background gases on both the arms. The relative influence of each factor is determined empirically and of course it is possible to add fixed resistances in the appropriate adjacent bridge arms to decrease the relative contribution of the filament resistance change to the bridge unbalance sensitivity. It is also possible to use different type filaments in the cells to emphasize the desired effect.

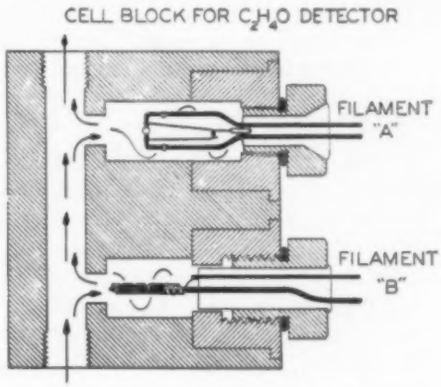

Figure 4 — These detector filaments and cell sizes were designed to measure ethylene oxide in carbon dioxide and air.

EXAMPLES OF USING DIFFERENT FILAMENTS

Figure 4 is a cross section of a detector cell block having different filaments in the two halves of the bridge. This filament and cell size combination was used to measure ethylene oxide in CO_2 and in mixtures of CO_2 and air. Ethylene oxide is used as a sterilizing agent and is rendered safe for handling by mixing with CO_2. High pressure cylinders are filled with the desired mixture. Because of the different vapor pressures of

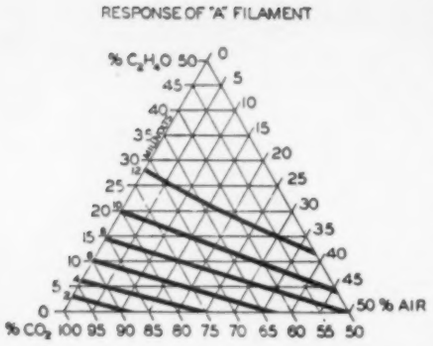

Figure 5 — Response of "A" filaments to various mixtures of ethylene oxide, carbon dioxide, and air, increases with carbon dioxide concentration.

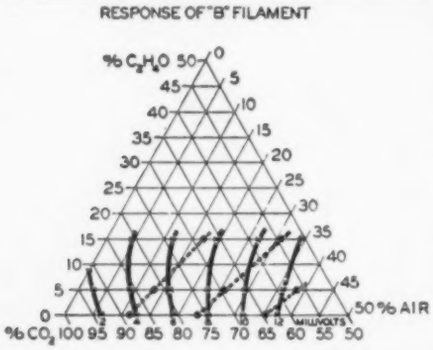

Figure 6 — Response of "B" filaments to various mixtures of ethylene oxide, carbon dioxide, and air, decreases with carbon dioxide concentration.

the two compounds, special eduction tubes are used to obtain a fairly constant ratio as the mixture is used from the cylinder.

In practice, the sterilization chamber is partially evacuated and refilled with the mixture from the cylinder. It is therefore desirable to be able to measure the concentration of ethylene oxide in either the CO_2 as it comes from the supply tank or in the sterilizer atmosphere where an unknown amount of air might be present.

Figure 5 shows the response of the "A" filaments to various mixtures of C_2H_4O, CO_2, and air. Response is influenced by the CO_2-to-air ratio and is higher at high CO_2 concentrations.

Figure 6 gives the response of the "B" filaments to the same mixtures at two filament temperatures. The slope of the curves can be shifted as shown, by varying the filament temperatures. These filaments give greater response at low CO_2 concentrations. By combining the two types of filaments in a four arm bridge and selecting the optimum filament temperature it should therefore be possible to achieve selectivity to C_2H_4O.

Figure 7 demonstrates that this assumption is correct since the combination responds to the concentration of C_2H_4O present and ignores changes in background gas from a 50-50 air-CO_2 mixture to 100 per cent CO_2.

It is interesting in this case to look at the physical properties of the CO_2 and C_2H_4O which enter into the equation given.

In the heat lost by convection the density is usually considered a good index. However in this case each compound has a molecular weight of 44. No data was found for the viscosity of C_2H_4O in the gas phase, but the time required to flush this gas in and out of the cells indicated it to be much different than CO_2. It was this difference which made the method applicable to this problem.

In addition to these applications this technique has been applied to the measurement of H_2 in steel furnace atmospheres. The measurement of H_2, CO_2 and CH_4 has been accomplished in a gas mixture of these three gases with air or nitrogen. Similar problems in which the gas mixture contains as many as seven components are being investigated.

In general, reproducible results can be obtained within approximate-

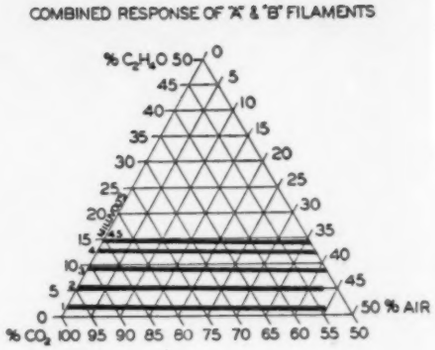

Figure 7 — By combining the two types of filaments in a four-arm bridge and selecting optimum filament temperature, selectivity to ethylene oxide is achieved. The combination responds to the concentration of ethylene oxide and ignores changes in background gas from a 50-50 air-Co_2 mixture to 100 per cent CO_2.

ly ± 2 per cent of a full scale reading.

The range of the instrument can be as low as 0 to 10 per cent gas or as high as 0 to 100 per cent gas. Special scales with suppressed zero make it possible to expand the desired portion of the range, for example, to make full scale equal to 80 to 100 per cent gas.

To realize the performance given here, the variation in concentration of the interfering gases should not be greater than about ± 5 per cent from its average value. The average value may be anywhere from 5 to 95 per cent.

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3. *"Heat Transfer Phenomena,"* by R. C. L. Bosworth. John Wiley and Sons, N. Y. Associated General Publications Pty Ltd., Sydney, Australia, 1952.

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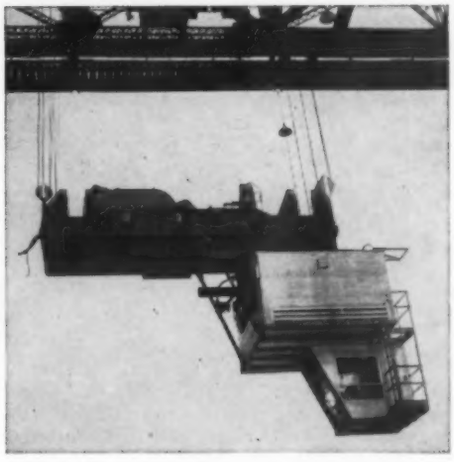

Operating records of several steel companies prove that you can add greater ore handling capacity practically and economically. In recent years, these companies installed Dravo replacement man trolleys on their existing bridges and immediately realized these benefits: Increased free-digging hourly tonnage rates (in one case, doubled), faster operating cycles, no blast furnace shutdowns since installation took less than 24 hours! Most important, this greatly improved performance was obtained at ⅛ the cost of a new bridge.

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GENERAL ELECTRIC *Control*

For fast, accurate performance, low operating costs, specify General Electric d-c control for your crane

If you're looking for the ultimate in crane control—from high-speed lowering to pin-point spotting, you want General Electric d-c crane control!

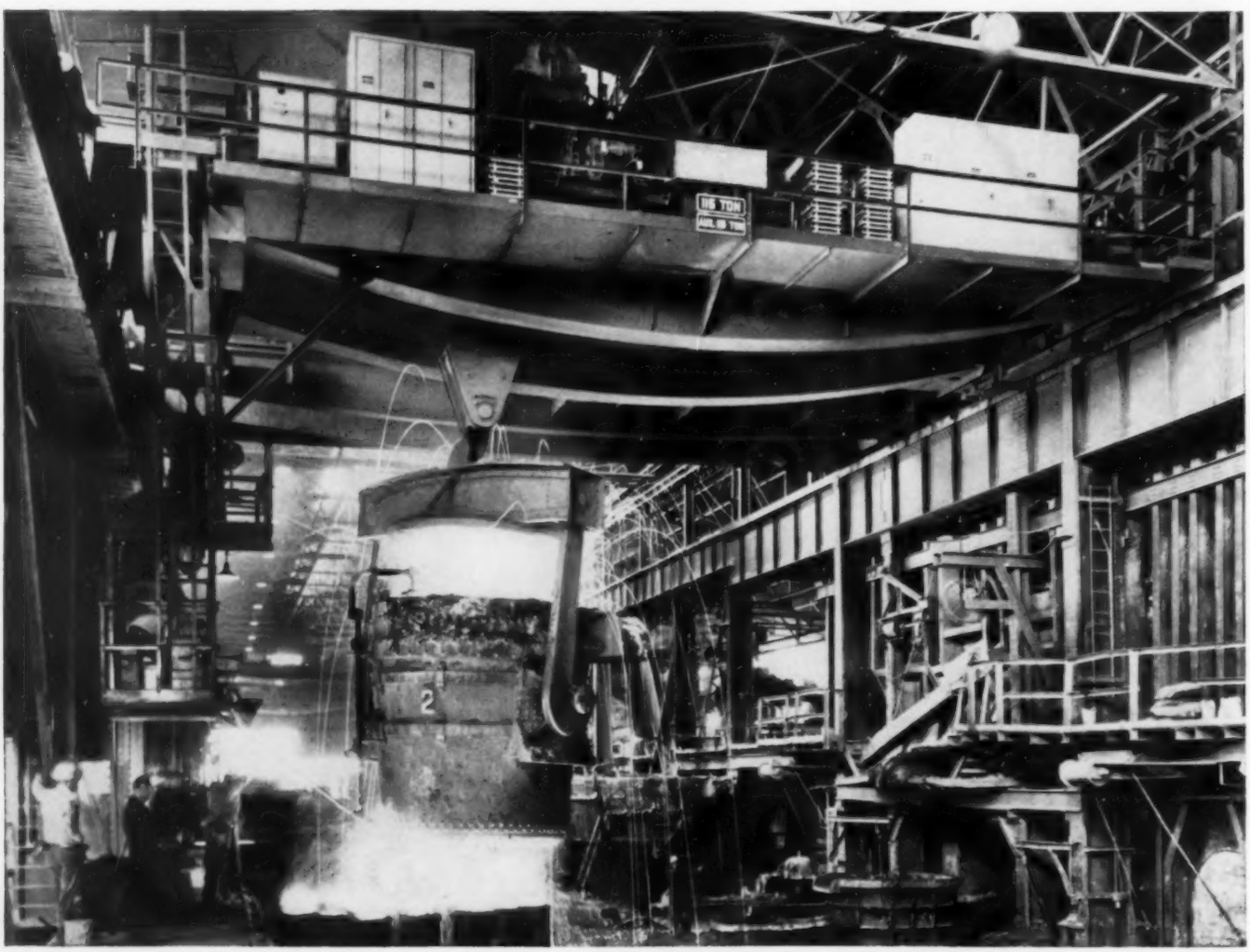
In designing the complete electrical system of your crane, G-E engineers work closely with your crane manufacturer to assure completely co-ordinated equipment. This integration of all mechanical and electrical components assures you of top crane operation, minimum downtime, and lower over-all operating costs. And because G.E. has a complete line of crane controls you are certain to get performance tailored to your specific operation.

ACCURATE HOIST CONTROL for every speed and load is assured with G-E d-c drives. Operational features, such as, five distinct speed points, dynamic braking, automatic acceleration and deceleration, and non-cycling operation provide you with a fast, efficient system.

PRECISION BRIDGE AND TROLLEY CONTROLS offer automatic acceleration, smooth reversal of motion without motor overload, and built-in automatic protection against motor overloading.

MINIMUM REPLACEMENT is required with General Electric d-c crane control. Each control component is tested under severe operating conditions and proved for the job before delivery.

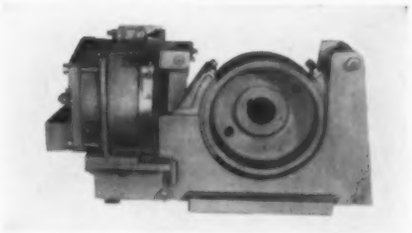
TAKE ADVANTAGE of these benefits by specifying G-E control for your next crane. Your G-E sales engineer will be happy to work with you and your crane manufacturer to engineer the right drive system. Industry Control Dept., General Electric Co., Roanoke, Va.



News for the steel industry

These G-E control products have top features for steel mill use:

DC BRAKES



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REMOVABLE LININGS—linings can be replaced in minutes, without removing the entire shoe assembly.

ARMATURE GAP INDICATOR—easily visible indicator shows when to adjust for lining wear.

MANUAL RELEASE—a simple and convenient method is provided for manually releasing the brake.

DRUM SWITCHES

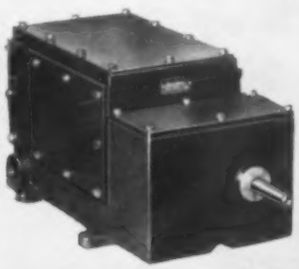
DOUBLED CONTACT LIFE—each contact is reversible and may be turned to receive wear on each side, thereby reducing replacement costs.

FAST EASY INSTALLATION—conduit boxes have knockouts in bottom, sides, and back to simplify installation.

REDUCED MAINTENANCE TIME—easily removable covers allow complete access to all working parts.

INTERCHANGEABLE MECHANISMS—standard horizontal handle may be replaced by rope wheel, vertical handle, or switchboard mechanism.

LIMIT SWITCHES



HEAVY DUTY CONSTRUCTION—able to stand up under punishment of severe shock, vibration, moisture, and dust conditions.

REDUCED MAINTENANCE—there are no shunts or drum-type segments to replace or maintain.

LONG LIFE—each double-break, silver contact is independently adjustable for opening and closing.

SIMPLE TO CONNECT AND ADJUST—cover is easily removed to allow access to terminals plus ample wiring space for conduit connection.

MASTER SWITCHES

RUGGED CONSTRUCTION—cast-aluminum cover protects cams and contacts from dirt and dust and accidental rough handling.

FLEXIBLE—may be used with reversing or non-reversing controllers and is available with up to 12 circuits.

EASILY REMOVABLE CONTACTS—the stationary and movable contacts may be removed easily without disturbing the wiring.

POSITIVE MAKE OR BREAK—design of contact mechanism assures positive make or break.

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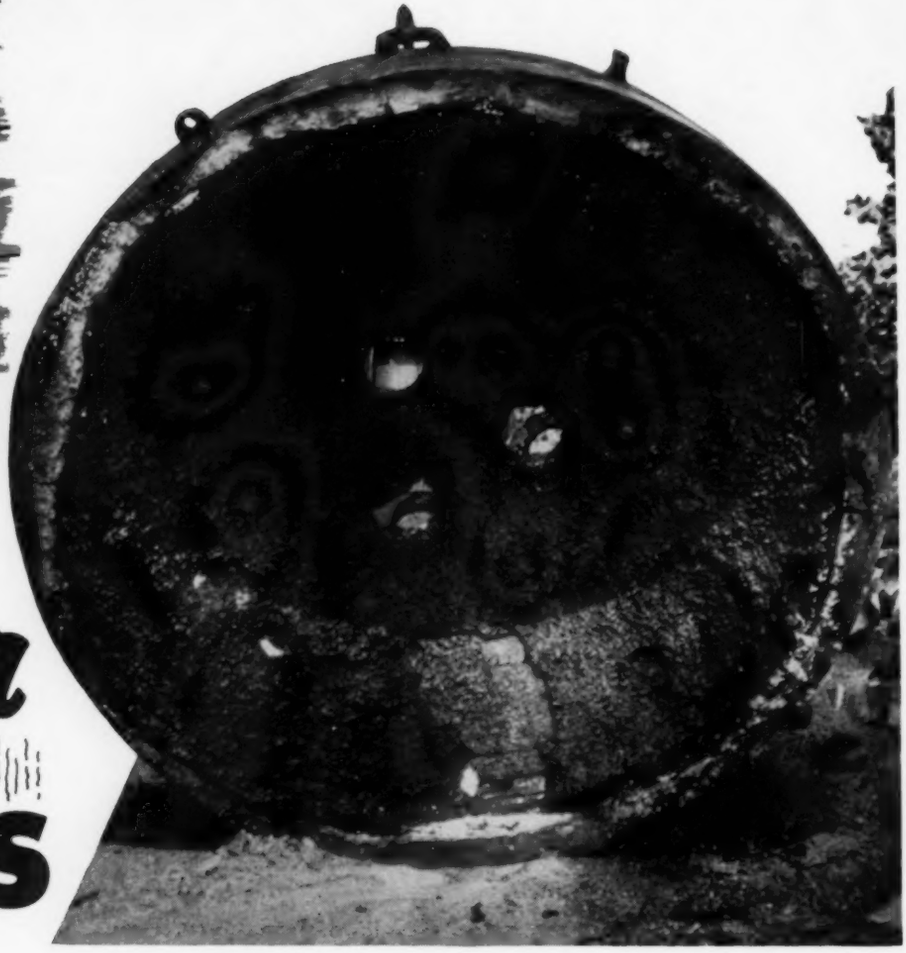
plastic firebrick roofs
33 heat average

mullite plastic
116 heat average

TAYCOR Ramming Mix
first roof—241 heats
second roof—254 heats

Roof of TAYCOR Ramming Mix for 1000-lb. direct arc furnace after 254th heat.



Extra HEATS

gained by TAYCOR roofs for direct arc furnace

The Fahralloy Company, Harvey, Illinois, operates a 1000-lb. basic direct arc furnace, melting 30-35 heats of heat and corrosion resistance alloys per week. Usual charge is 1500 lbs.

After changing from acid to basic furnace practice, tests were run with the following results: Silica roofs averaged 13 heats. Super-duty plastic firebrick roofs averaged 33 heats. Rammed roofs of competitive mullite plastic averaged 116 heats.

The first TAYCOR rammed roof set a record of 241 heats. The next TAYCOR roof jumped the record to 254 heats, some of them up to 3600-lb. triple sized ones.

Among the TAYCOR advantages reported by Fahralloy are:

Longer roof life
No dripping
Longer sidewall life
Less slag

Try TAYCOR Ramming Mix for your next direct arc roof. Let the Taylor field engineer in your area give you full details.

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Installation of five EF special atmosphere continuous furnaces bright annealing stainless steel wire.

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Date-line Diary...

July 2

▲ The AISI reports that the operating rate of the steel industry for the week of July 2 is scheduled at 13.0 per cent of capacity. This is equivalent to 320,000 tons compared with 2,090,000 tons one week ago and 2,073,000 tons one year ago. Index of production for the week is 19.9.

▲ Statistics released by the Resistance Welder Manufacturers Association revealed that new business to members for May totaled more than $3,500,000, resulting in a 103 per cent increase for 1956 over the same period in 1955.

July 3

▲ Installment credit outstanding at May 31, 1956 totaled $28,600,000,000 or $4,400,000,000 above a year ago, taking into account a total of $331,000,000 increase during May, 1956.

▲ Auto production during the first half of 1956 dropped to 3,192,206 cars, about 25 per cent lower than a year ago; in June General Motors produced 229,180 cars, 5.1 per cent below May output; Ford Motor 128,630 cars, 9.2 per cent reduction from May; and Chrysler's total of 63,304 cars was 14.2 per cent less than May.

July 5

▲ The AISI reports estimated payroll for the iron and steel industry for May, 1956 at $333,570,000. Average hourly payroll cost of wage earners was $2.619 for each hour worked during May compared with $2.621 in April. In addition to the above, the hourly cost for pensions, social security, and insurance amounted to 21.3¢ per hour. Working hours averaged 40.1 hr per week in May compared with 39.7 hr per week in April. Estimated number on payroll was 679,800.

▲ Steel prices were boosted $5 to $16 a ton by companies not on strike to cover future retroactive raises.

▲ Copper price to Canadian consumers was lowered 5⅜¢ a pound to 40¢ by Inco. The price to U. S. industry is unchanged at 46¢ a pound, level with that charged by major U. S. producers.

▲ Labor negotiations underway between Canadian steel producers and workers have been lagging pending the outcome of the U. S. steel strike developments. Union Drawn Steel Co. Ltd., Hamilton, a subsidiary of the Republic Steel Corp., and the Marmora Mining Co., Marmora are shut down by walkouts in sympathy with the U. S. strike; workers at the Steel Co. of Canada, Hamilton, voted a strike authorization in event negotiators fail to reach a settlement of their wage demands; and contract talks are underway between the United Steelworkers and the Algoma Steel Co., Sault Ste. Marie, Ontario, and the Dominion Steel & Coal Corp., Sydney, Nova Scotia.

▲ The AISC reports shipments of fabricated steel for May, 1956 totaled 306,223 tons, bookings totaled 358,271 tons, leaving a backlog of work at May 31, of 2,895,660 tons.

July 6

▲ Dravo Corp. announced plans to erect a new iron ore sintering plant, with a capacity of 2400 tons daily, at Armco's Ashland, Ky., works.

▲ Stockholders of Mesta Machine Co. approved a proposal setting the concern's authorized debt limit at $10,000,000.

▲ An advance report of the 1954 Census of Manufacturers released by the Bureau of Census, states that during 1954 the metal foil industry shipped products valued at $180,000,000 an increase of 197 per cent from 1947. Average employment increased 43 per cent to a total of 6700 employees in 1954.

July 9

▲ AISI reports that shipments of finished steel products from steel mills during May, 1956 were 7,764,776 tons.

▲ Copper was reduced to 37½¢ a pound by custom smelters, off 2½¢ from the prevalent 40¢ established May 29.

▲ The Bureau of Statistics reported that the production of Canadian pig iron totaled 303,520 tons in June, 1956, compared with 275,049 tons a year ago, steel ingot output increased to 430,867 tons in June, 1956, compared with 381,367 tons a year ago.

▲ The AISI reports that the operating rate of the steel industry for the week of July 9 is scheduled at 12.7 per cent of capacity. This is equivalent to 312,000 tons compared with 302,000 tons one week ago and 2,202,000 tons one year ago. Index of production for the week is 19.4.

July 10

▲ Allegheny Ludlum Steel announced it is making available, for the first time, to the metal working industry hot extruded tool and high speed steel shapes.

▲ Phelps Dodge Corp. announced a 6¢ per pound price slash in copper to 40¢ a pound. This is the first decline from the 46¢ per pound level established in February.

▲ The Departments of Commerce and Labor reported employment in June set a new high with jobholders totaling 66,500,000, an increase of 1,300,000 over May, 1956 and 2,500,000 more than June, 1955.

July 11

▲ The Commerce Department reported that construction outlays in June rose to $4,000,000,000, 8 per cent above May, 1956, and 1 per cent above June, 1955.

▲ Stock at the end of May in manufacturing, wholesale and retail lines were valued at $85,800,000,000 an increase of $100,000,000 over a month ago, but $7,200,000,000 over a year ago reported the Department of Commerce; sales for May totaled $54,700,000,000, $2,400,000,000 over April, 1956, $3,600,000,000 over a year ago.

▲ The stock of John Robertson Co., Brooklyn manufacturer of lead extrusion presses and related equipment has been acquired by the E. W. Bliss Co.

July 12

▲ President Eisenhower disclosed that farm surplus disposal for the January-June, 1956 period soared to $1,200,000,000 with a loss of about $471,000,000, compared with a total of $491,000,000 disposal during the previous six months with a loss of about $297,000,000.

▲ Anaconda and Kennecott reduced their price on copper to 40¢ per lb in line with price established earlier by Phelps Dodge. Custom smelters reported fairly satisfactory business at the level 37½¢ per lb for August delivery.

July 13

▲ Leading producers of hard coal raised prices 25¢ to 50¢ a ton at the mines.

▲ Custom smelters boosted price of copper to 38¢ a lb, narrowing the gap between their price and the 40¢ level maintained by the U. S. producers, and reflects the first upward turn since the price fell from 55½¢ per lb in mid-March.

▲ Prices for steel products were jacked up by warehouses following the soar in demand since the strike, with increases ranging from $5 to $12 a ton.

July 16

▲ Commerce Department officials stated that the national production of goods and services in the second quarter of 1956 showed an increase over the preceding quarter and now estimate the gross national product figure at the annual rate of $403,400,000,000 for the first quarter of this year, a rise from the previous estimate of $398,600,000,000.

▲ The AISI reports that the operating rate of the steel industry for the week of July 16 is scheduled at 14.6 per cent of capacity. This is equivalent to 360,000 tons compared with 317,000 tons one week ago and 2,195,000 tons one year ago. Index of production for the week is 22.4.

July 17

▲ F. W. Dodge Corp. reports contract awards for future construction during June in the 37 states east of the Rockies totaled $2,197,815,000, 3 per cent below June, 1955. Contracts for future homes construction fell to $828,218,000, 13 per cent less than last year. Reports for the first six months of 1956 show total awards of $13,198,959,000 (a new record); non residential up 11 per cent, residential up 5 per cent and heavy engineering up 21 per cent.

▲ The U. S. Government Export-Import Bank granted $10,000,000 credit to August Thyssen-Huette, AG, a West Germany steel company to be used for equipment and technical help in the U. S. including a semi-continuous billet mill, a bar mill, auxiliary equipment for a cold roll mill, an electrolytic tinning line and a galvanizing line, thus enabling the company to become the largest flat rolled steel producer in Germany by 1958.

▲ An advance report of the 1954 Census of Manufacturers released by the Bureau of Census, states that during 1954, the manufacturers in the bolts, nuts, washers, and rivets industry shipped products valued at $699,000,000 an increase of 51 per cent over the 1947 total. Average employment increased 9 per cent to a total of 53,700 employees in 1954.

July 18

▲ Ralph Cordiner, president of GE, announced that the company's sales volume for the first half of 1956 was 17 per cent above a year ago, and that the net rose to $1.30 per share from $1.24 last year.

▲ Shipment of iron ore down the Great Lakes last week amounted to only 340,977 tons compared with 3,068,963 tons last year. About 5,000,000 tons of ore production has been lost since the strike began July 1st, since about 200 of the 255 vessels comprising the ore fleet have been idled.

▲ Harvey Machine Co. completed financing arrangements for the construction of a $65,000,000 primary aluminum plant at The Dalles, Ore. Upon operation of the plant the company will become the fifth U. S. producer of primary aluminum.

▲ Kaiser Steel Corp. at Fontana, Calif. has placed an order with Westinghouse Electric Corp. for a 10,000-hp electric motor and other equipment totaling $3,000,000 with delivery scheduled for October, 1957.

▲ The Bureau of Mines, U. S. Dept. of the Interior, reports that the consumption of scrap during May totaled 6,492,000 gross tons and pig iron 6,064,000 gross tons, a slight decrease from the total consumption of these products in April, 1956.

▲ Deliveries of new domestic freight cars in June totaled 5550 cars, compared with 6667 in May, 1956 and 3015 in June 1955. Orders in June totaled 2859 compared with 2403 in May. Backlog of cars on order as of July 1, stood at 129,409 cars.

▲ The Aluminum Association reported primary production of aluminum during June totaled 291,452,517 lb in comparison with 301,600,064 lb in May, 1956 and 255,265,003 lb in June, 1955.

July 19

▲ Dr. Fritz-Aurel Goergen, president and general managing director of Phoenix-Rheinrohr, AG, West Germany, reported 2,200,000 tons of raw steel production for the fiscal year 1954-1955 and 1,595,000 tons from October 1955 to June 1956. West Germany's output of raw steel totaled 11,299,510 tons for the first half of 1956, compared with 10,284,374 tons in the same period, 1955.

July 20

▲ Federal spending in the fiscal year ending June 30 totaled $66,400,000,000, revenues for the year were $68,100,000,000 with a surplus at the end of the year of $1,700,000,000.

▲ An extension to September 11, 1956 has been made by Interlake Iron Corp. for the exchange of Interlake stock on the basis of 0.4666⅔ of a share of Interlake for each share of Globe Met. Exchange is to be negotiated through the depositary, Central National Bank of Cleveland.

July 23

▲ The Industrial Heating Equipment Assn. reported that orders for industrial furnaces during June amounted to $25,597,087, compared with $10,616,234 for June, 1955. Included in these figures are orders received for steel mill furnaces, reported semi-annually in June and December. Steel mill figures include $20,849,106 for the first six months of 1956, against $4,804,418 in 1955.

▲ National production of goods and services rose sharply in the second quarter. President's Council of Economic Advisers estimated output at $408,500,000,000 annually or $5,100,000,000 over the first quarter rate, and $21,100,000,000 over the second quarter level in 1955.

▲ David J. McDonald, president of United Steelworkers, declared the steel industry can afford to meet union demands without price increase and without setting off any inflationary effect whatsoever. Abandoning its "hands-off" policy about pricing of steel products, the union issued a two-volume economic study which it said "reveals a disturbing irresponsibility in the pricing and profit-margin policies of the steel industry."

▲ The AISI reports that the operating rate of the steel industry for the week of July 23 is scheduled at 15.6 per cent of capacity. This is equivalent to 385,000 tons compared with 377,000 tons one week ago and 2,190,000 tons one year ago. Index of production for the week is 24.0.

July 24

▲ The Navy announced that Bethlehem Steel Co. will construct its first nuclear-powered surface ship, a guided missile cruiser, at the Quincy, Mass. yard, as a part of the Navy's 1956-57 shipbuilding program.

▲ According to Lloyd's Register of Shipping, on June 30, 1956, 1530 vessels totaling 7,200,000 gross tons, were under construction in the free world,

STEEL COMPANY QUARTERLY FINANCIAL REPORTS — APRIL 1, 1956 TO JUNE 30, 1956

	1956 Net sales	1956 Net profit	1956 Earnings per share	1955 Net sales	1955 Net profit	1955 Earnings per share
Acme Steel Co.	$ 32,282,958	$ 2,008,053	$1.01	$ 28,423,722	$ 1,851,569	$0.93
Barium Steel Corp.	28,857,882	1,445,043	0.44	18,957,882	(94,594)	Loss
Bethlehem Steel Corp.	670,353,986	50,298,227	5.05	550,923,846	47,006,062	4.74
Copperweld Steel Co.	27,322,000	902,099	1.07*	19,806,000	598,667	1.05
Eastern Stainless Steel Corp.	25,103,450	1,678,801	2.89	17,342,899	1,133,379	1.95
Granite City Steel Co.	35,616,136	3,753,021	1.76	29,365,887	3,196,499	1.50
Inland Steel Co.	201,237,538	14,944,932	2.70	165,382,397	12,987,097	2.40
Interlake Iron Corp.	27,136,293	2,144,144	1.10	26,108,519	2,405,623	1.23
Jones & Laughlin Steel Corp.	213,418,000	17,350,000	2.66	179,329,000	12,926,000	2.01
Kaiser Steel Corp.	53,640,418	7,608,596	2.20	47,803,151	5,571,925	1.57
Lukens Steel Co.	27,454,654	2,180,492	6.86	19,262,642	556,906	1.75
National Steel Corp.	177,033,747	14,858,824	2.01	157,584,750	11,829,410	1.61
Pittsburgh Steel Corp.	51,964,579	2,311,483	1.34	47,427,043	1,665,036	0.90
Republic Steel Corp.	351,454,168	26,491,060	1.71	305,293,343	22,944,806	1.50
Rotary Electric Steel Co.	15,433,716	557,860	0.72	14,401,891	1,064,436	1.38
Sharon Steel Corp.	.....	2,067,761	1.88	.....	.....	.....
United States Steel Corp.	1,168,747,055	104,389,496	1.83	1,094,833,924	105,225,558	1.85
Wheeling Steel Corp.	76,213,000	6,119,000	2.97	65,126,130	3,763,273	1.74

*No. shares increased.

compared with 1349 units of 6,100,000 gross tons, on June 30, 1955.

July 25

▲ According to the government index, living costs in June, 1956 were the highest in history, reaching 116.2 per cent of the 1947-49 average. The general increase will result in wage boosts for approximately 500,000 workers.

July 26

▲ Prices of steel scrap advanced $6 a ton in Pittsburgh and $5 a ton in Chicago, with heavy purchases anticipating that steel mills would pay considerably higher prices when operations are resumed.

▲ The U. S. Dept. of Commerce announced that shipments of gray iron castings during April, 1956 totaled 1,218,000 short tons, approximately 3 per cent below March, 1956 and 6 per cent below April, 1955 level, for May shipments totaled 1,248,000 short tons, 2 per cent above April, but 5 per cent below May 1955. Shipments of steel castings totaled 164,000 tons in April, 4 per cent below March, but 36 per cent above April 1955 figure, and in May shipments totaled 178,000 tons, 9 per cent above April and 46 per cent above May, 1955.

July 30

▲ The strike-ending steel labor agreement provides wage increases averaging 10.5 cents an hour in the first year, 9.1 cents in each of next two years; cost-of-living increases up to 4 cents an hour total; layoff pay plan of 65 per cent of take-home pay up to 52 weeks for laid-off employees with two or more years service; Sunday premium pay of time and 1/10 the first year, time and 1/5 the second, and time and 1/4 the third; union shop—new workers must join, present and future members must retain membership; and other benefits including a seventh paid holiday, higher premium pay for afternoon and night shift and for holiday work, increased pension and insurance benefits, jury pay and higher vacation pay.

▲ The AISI reports that the operation rate of the steel industry for the week of July 30 is scheduled at 17.5 per cent of capacity. This is equivalent to 431,000 tons compared with 419,000 tons one week ago and 2,098,000 tons one year ago. Index of production for the week is 26.8.

▲ Pittsburgh Coke & Chemical Co.'s report for the quarter ended June 30, 1956 showed sales amounting to $19,512,000, net profit $1,133,000, or 90¢ per common share, compared with the same period of 1955 with sales $16,294,000, net profit $1,073,000, or $1.01 per share. Shares outstanding in 1956 totaled 1,129,401, in 1955, 948,193.

▲ Sales of the Allis-Chalmers Mfg. Co. for the first half of 1956 totaled $294,264,807, profits amounted to $11,855,735, and for the same period of 1955, sales totaled $267,040,844, with profit of $12,562,932.

▲ Second quarter of 1956 results of the Blaw-Knox Co. showed net income of $2,137,930, or $1.37 per share on sales of $40,000,000, compared with earnings for the same period in 1955 of $826,763 or 53¢ per share on sales of $30,000,000.

▲ Westinghouse Electric Co., for the second quarter of 1956, reported sales totaling $380,731,000, net income of $6,862,000 or 38¢ per share, compared with sales of $388,258,000, earnings of $16,635,000 or 98¢ per share in the same quarter of 1955. Lower earnings in 1956 reflect the non-recurring post-strike manufacturing and distribution costs.

July 31

▲ Jessop Steel Co. is negotiating for the acquisition of the Green River Steel Corp., Owensboro, Ky. Talks are in preliminary stages with no transaction imminent.

▲ The Commerce Department reported that U. S. exports for June, 1956 rose to $1,517,000,000, $4,000,000 above May, 1956 and $326,000,000 over June of 1955.

▲ The Government plans to pay premium prices, covering production costs, to foreign and domestic firms which expand nickel output, in order to increase nickel supplies available to the U. S. from 300,000,000 lb at the present time to 440,000,000 lb annually by 1961.

▲ Roger M. Blough, chairman of the U. S. Steel Corp., estimated steel operations will average only about 60 per cent of capacity during the third quarter of 1956, after taking into consideration the 15 per cent output reached in July.

▲ Resistance Welders Manufacturers Assn. reported new business for members of approximately $4,000,000 for June, 1956, shipments in June amounted to nearly $4,500,000, with $20,000,000 backlog at the end of June.

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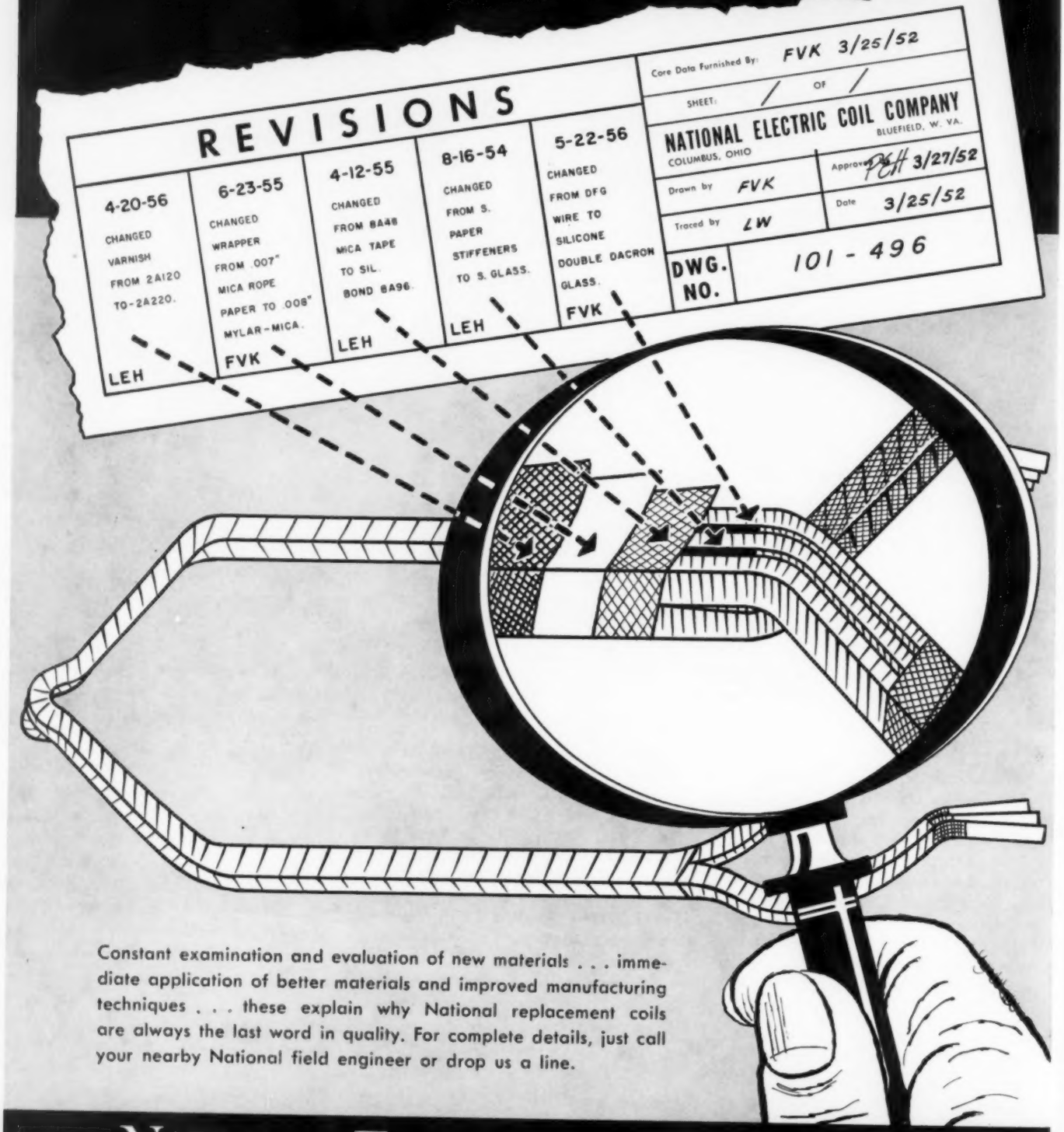

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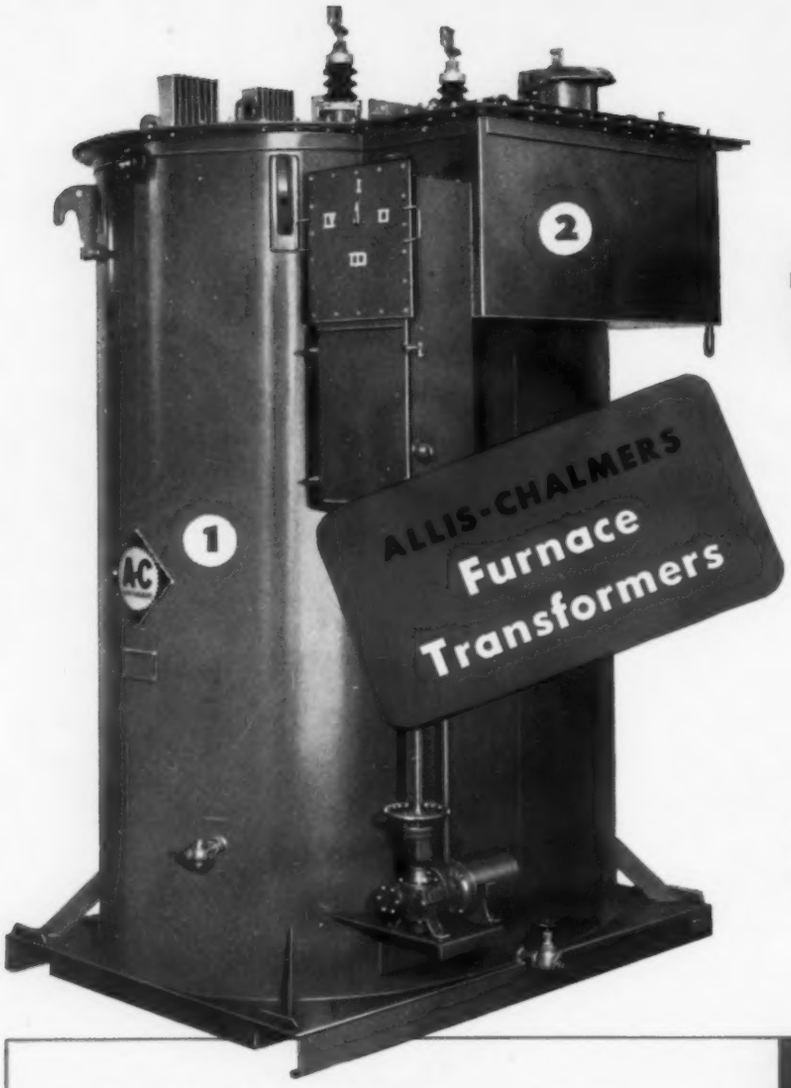

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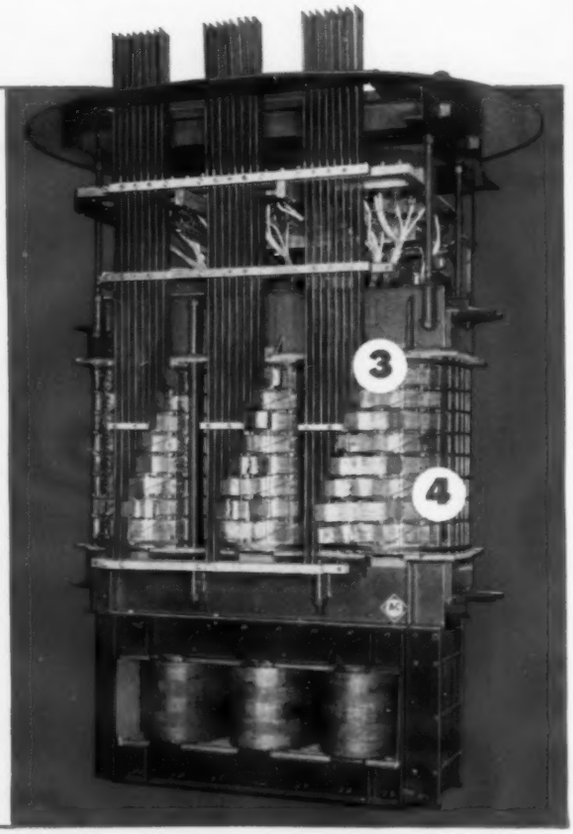

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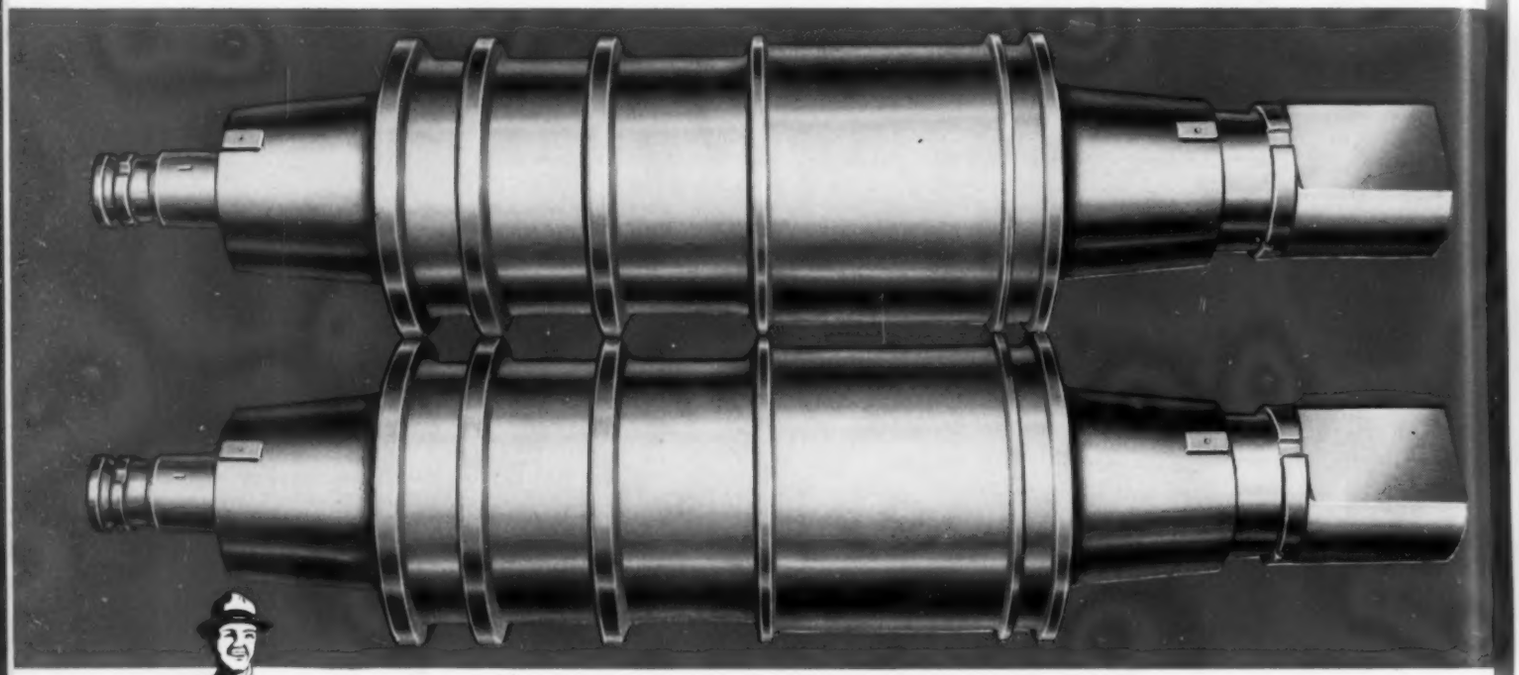


The service life of Ohio Rolls begins with integrated planning by a group of specialists analyzing roll requirements . . . Ohio's designers—metallurgists—chemists —engineers—foundrymen—and inspectors . . . working directly with *your* Ohio Roll Representative. Their job is to make sure that Ohio Rolls meet rigid job specifications—in design, metal analysis, hardness, tensile strength, dimension and finish. These are operations that require specific planning to make certain that Ohio Rolls deliver High Tonnage . . . give Long Life . . . and Satisfactory Service.

OHIO ROLLS SERVE THE WORLD

When you need rolls—large or small—call in your Ohio Roll Representative. He understands production requirements, and he can help you solve your roll problems quickly and efficiently.

shaping metal for all industry

Carbon Steel Rolls	Ohio Double-Pour Rolls	Nickel Grain Rolls
Ohioloy Rolls	Chilled Iron Rolls	Special Iron Rolls
Ohioloy "K" Rolls	Denso Iron Rolls	Nioloy Rolls
Flintuff Rolls		Forged Steel Rolls

THE OHIO STEEL FOUNDRY COMPANY

LIMA, OHIO Plants at Lima and Springfield, Ohio

ORS

Industry News...

ARMCO TO ADD NEW OPEN HEARTH FURNACE AND PIPE PILING PLANT AT MIDDLETOWN

▲ Plans for a nine per cent expansion in steel ingot capacity at its Middletown Works has been announced by Armco.

The additional steel ingot production will come from a new open hearth furnace, to be completed by mid-1957. Cost of the 300-ton furnace will be approximately $2,000,000.

The new furnace will produce 17,000 tons of steel a month. When completed, it will be the third new open hearth furnace to be put into operation at Armco's Middletown Works in an 18-month period. The company placed a new furnace into operation in January of this year and started a second one in March.

The building and foundations for the new furnace are already in place. Foundations were added and preparatory work was done when the last two furnaces were built.

The new furnace is part of an overall Armco expansion program that will increase the company's annual steel producing capacity to 6,200,000 tons by early 1958.

In addition the company is planning construction of a new $800,000 plant which will increase its production of spiral-welded steel pipe piling by more than one-third.

The new plant is already under construction adjacent to the company's Middletown Fabricating Plant No. 2. Limited production of pipe piling will begin in October and the plant should be completed by the end of the year.

Armco's present facilities for producing spiral-welded pipe at Middletown will be continued in full operation.

PITTSBURGH STEEL PLANS MONESSEN BILLET MILL

▲ A modern $6,000,000 billet mill will be installed in Pittsburgh Steel Co.'s Monessen, Pa., Works. President Avery C. Adams said that construction on the six-stand, continuous 30-in. mill will begin next December. Full operation is expected in the latter part of 1957.

The new mill, which will replace steam driven equipment more than 45 years old, is an addition to the $15,000,000 cost reduction program now being completed at Monessen. Erection of the mill, to be installed in existing buildings, will cause no appreciable interruption to production and will not require new financing.

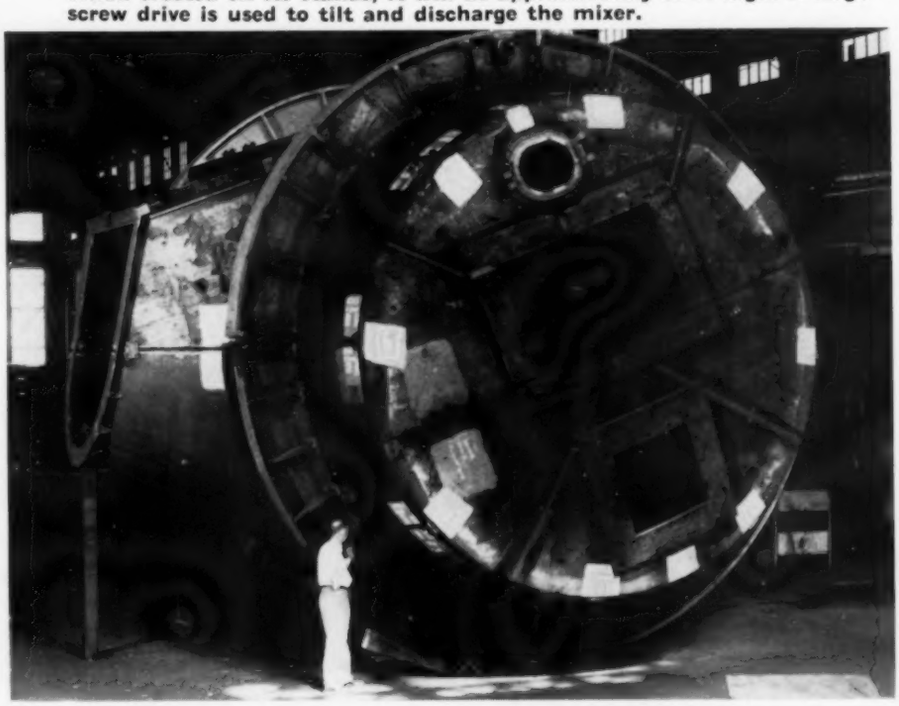
United Engineering and Foundry Co. has been awarded the contract for the mill machinery. The main electrical drives, including six 1750 hp motors, will be provided by General Electric Co. Contracts for auxiliary electrical equipment and switchgear have been awarded to Westinghouse Electric Corp. Giffels & Vallet, Inc. of Detroit will perform detailed engineering required for the mill.

With three vertical and three horizontal mill stands in a straight line, the new mill will be able to roll blooms from 9 x 10-in. down to 4-in. squares and 3⅝-in. rounds.

Excessive downtime now required to change rolling sizes, which can amount to as much as an hour and 15 minutes per change of rolls, will be reduced to as little as two minutes on the new mill.

HOT METAL MIXER FOR LARGE STEEL PRODUCER

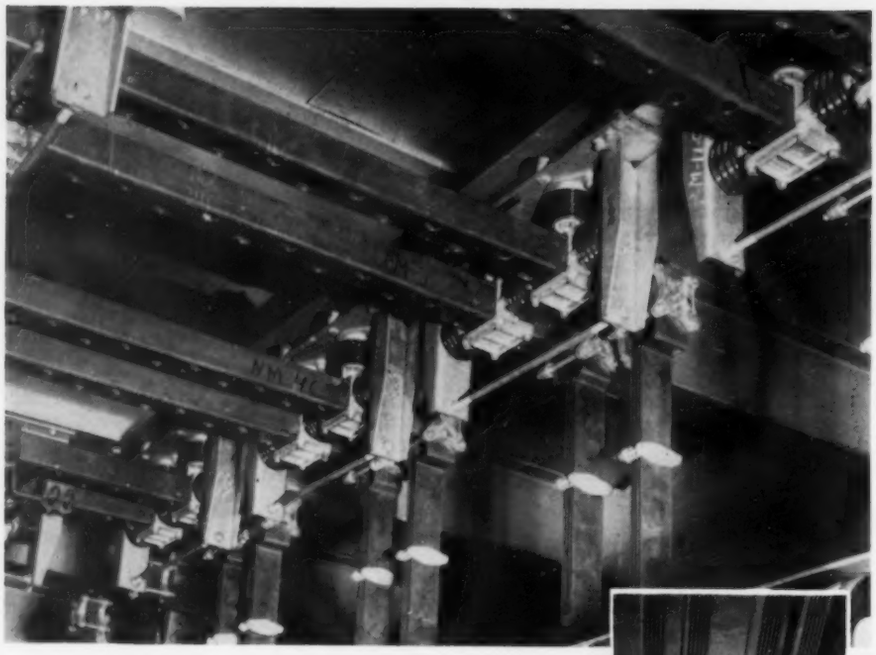
This 800-ton capacity hot metal mixer, built by Pennsylvania Engineering Corp., is of all-welded construction. The shell plates are 1⅛ in. thick and the shell is 20 ft in diameter inside. The two bands that go around the shell are 24 ft in diameter, and the overall length of the unit is 33 ft-6 in. When erected on its stands, it will be approximately 33 ft high. A large screw drive is used to tilt and discharge the mixer.

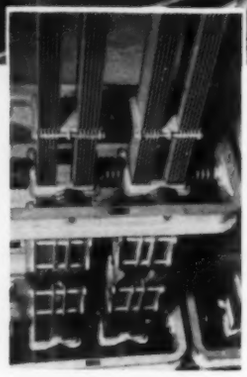


SHARON STEEL TO ADD ELECTRIC FURNACE SHOP

▲ A $6,000,000 electric furnace shop will be built by Sharon Steel Corp. at its Roemer Works, Farrell, Pa., which will double present capacity of the company to produce stainless and high alloy steel. Construction will be designed for the addition of a second furnace for future expansion.

Earlier this year the company reported the launching of a major program to add 350,000 tons of open hearth ingot capacity to its then capacity of 1,550,000 tons of open hearth and electric furnace steel. Included in the program was the enlargement of three open hearth furnaces to a capacity of 250 tons each.





Avoid Costly Down Time

with DELTA-STAR reinforced

BUS STRUCTURES

When properly designed, bus structures can be relied on to withstand severe short circuits without damage. Delta-Star reinforced bus structures are engineered to withstand the maximum forces that may be encountered, consistent with the capacity of your system. Extra strength is built in by using heavy reinforced construction with high grade wet process porcelain placed in compression, taking full advantage of the porcelain's greatest strength.

Delta-Star engineers will be glad to work out your bus problems and develop a layout to suit your specific requirements.

OTHER DELTA-STAR PRODUCTS
Used in Mills and Industrial Plants

- Crane Rail Supports
- Disconnecting Switches
- Terminators (Potheads)
- Plugs and Receptacles
- Spool Insulator Cable Supports
- Water Cooled Conductors and Fittings
- Interrupter Switches
- Power Connectors

DELTA-STAR ELECTRIC DIVISION

H. K. PORTER COMPANY, INC.

2437 Fulton Street · Chicago 12, Illinois · District offices in principal cities

With the completion of the open hearth furnaces and the addition of the electric furnace, the total ingot capacity of the company will be boosted to approximately 2,000,000 tons per year.

Sharon has awarded the contract for the design, engineering and construction of the facility to the American Bridge Division of U. S. Steel Corp. It is expected the unit will be in operation by January, 1958 and no additional financing is contemplated at this time, it was said.

ACME STEEL AGREES TO BUY NEWPORT STEEL

▲ Acme Steel Co. has agreed to purchase the property and net assets of Newport Steel Corp., subject to the approval of Newport stockholders.

Steelmaking facilities at Newport have an annual ingot capacity of 600,000 tons from open hearth and electric furnaces, with blooming and finishing mills for producing hot and cold rolled sheets, electric-weld line pipe and specialties, none of which are made by Acme Steel.

Upon completion of the purchase, Newport will be operated in its present locations at Newport and Wilders, Ky., as a division of Acme Steel.

Acme Steel expects to barge a limited quantity of semi-finished steel from Newport, Ky., to its Riverdale, Ill., plant to supplement its present supply of raw material, which is now furnished under contract by producers in the Chicago area, but not in sufficient quantities to permit Acme Steel capacity operations in times of high demand.

On the basis of present operations of Acme Steel and Newport Steel, the consolidated business would represent annual sales of approximately $170,000,000.

STEEL FIRM CHRISTENS NEW BLAST FURNACE

▲ Granite City Steel Co. formally christened its new blast furnace on May 17. The furnace was named "Marian" in honor of the wife of the company's board chairman and chief executive officer, John N. Marshall.

It is 229 ft, four in. high, and with a second, older blast furnace at Granite City will give the company an annual pig iron capacity of about 700,000 tons.

Granite City saves fuel, raises production and quality with Cities Service Heat Prover!

Nation's 14th largest steel producer uses Heat Prover on soaking pits, open hearth furnaces and on their annealing furnaces.

Granite City Steel burns enough fuel in one year to heat a five-room house for 38,000 years!

Obviously, if this fuel burns inefficiently, the loss could be staggering. But Granite City has no worries on that score. "Thanks to the portable Cities Service Heat Prover, we get better fuel efficiency, better quality, greater production than ever," they report.

"Because it provides a quick, highly accurate check of fuel-air ratio, the Heat Prover has proved invaluable in controlling combustion conditions in open hearth furnaces, soaking pits, and annealing and normalizing furnaces. In a matter of seconds it tells our engineers how efficiently the furnaces are working—whereas former tests often took hours and didn't provide as accurate a picture. Anyone in this business can probably benefit from this ingenious device."

Supplied and maintained free by Cities Service, the remarkable Heat Prover is today used and applauded by scores of major steel producers. If you'd like to learn how it could simplify your operation as it has theirs, talk with your local Cities Service Lubrication Engineer. Or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

20TH CENTURY BLOWGUN—a bazooka—is readied by technicians for tapping open hearths. They are part of Granite City's 4800 skilled employees.

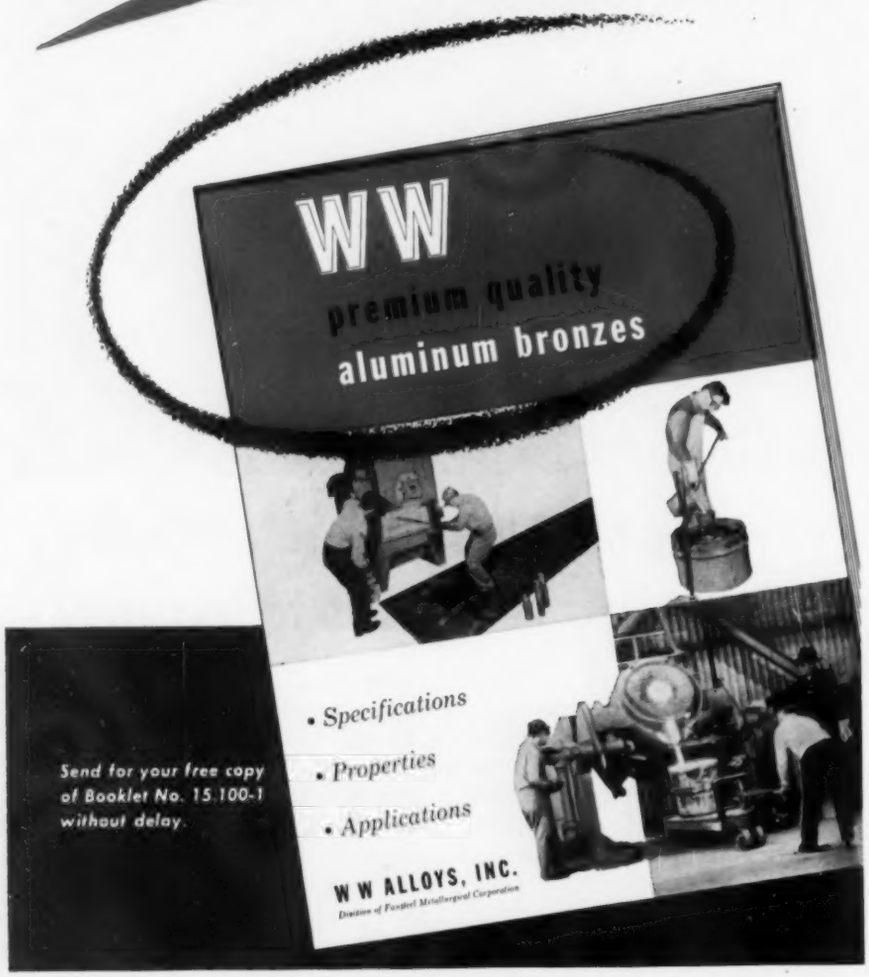
HEAT PROVER AT WORK at back of open hearth furnace. In minutes it provides accurate check on furnace efficiency—saves hours required by former testing.

CONTROL TOWER at blooming mill guides ingots as they pass through rollers. Granite City has capacity of 1,200,000 net tons of ingots annually.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

New · facts · figures · functions



It's hot off the press and packed with facts about the properties, composition and functions of WW Aluminum Bronzes. Steel men will be particularly interested in the description of aluminum bronze alloys used for heavy duty applications such as universal joint slippers (also available "cast-to-size"), guides and wear plates, screw boxes, breaker blocks, gears, worms, and worm wheels, table bearings, traverse nuts, manipulator link bushings, hydraulic valve parts, liners, welder dies, wedges, and many more.
You'll find a complete 17-page section of engineering data describing each grade, a Specification Index Chart for comparison, six pages of machining recommendations and tool geometry. Also included is information on our engineering and metallurgical consultation services, foundry and machine shop facilities.

WW ALLOYS INC.
11683 CLOVERDALE AVE.
DETROIT 4, MICHIGAN
Division of Fansteel Metallurgical Corporation

ACQUIRES OWNERSHIP OF NEW CASTLE PLANT

▲ Ownership of the huge New Castle, Pa., plant was acquired by Mesta Machine Co., from the General Services Administration of the U. S. Government. The transaction had the approval of the Justice Department and the Defense Department.

The property occupies a 50-acre tract of land containing 15 buildings. They include a foundry machine shop, boiler house, electric power plant, office building, and employment office including an infirmary. The total floor area of the buildings covers approximately 875,000 sq ft.

Facilities at the plant are designed and available for the production of rolling mill and steel plant equipment, machine tools, and heavy duty machinery.

WESTINGHOUSE TO BUILD DRIVE FOR KAISER MILL

▲ A 10,000-hp twin drive motor, will be built by the Westinghouse Electric Corp. for the 45 in. x 90 in. reversing slabbing mill at Kaiser Steel Corp.'s Fontana, Calif., plant.

The motor consists of two 5,000-hp d-c reversing motors operating at 40 to 80 rpm. The 44-ft-long motor stands 14 ft high and 16 ft wide. The order also includes a 4,000-hp motor for the edger roll in the slabbing mill.

Delivery of the motors, control and auxiliary apparatus to the mill is scheduled for October, 1957.

LUMMUS CO. LICENSES THERMAL RESEARCH

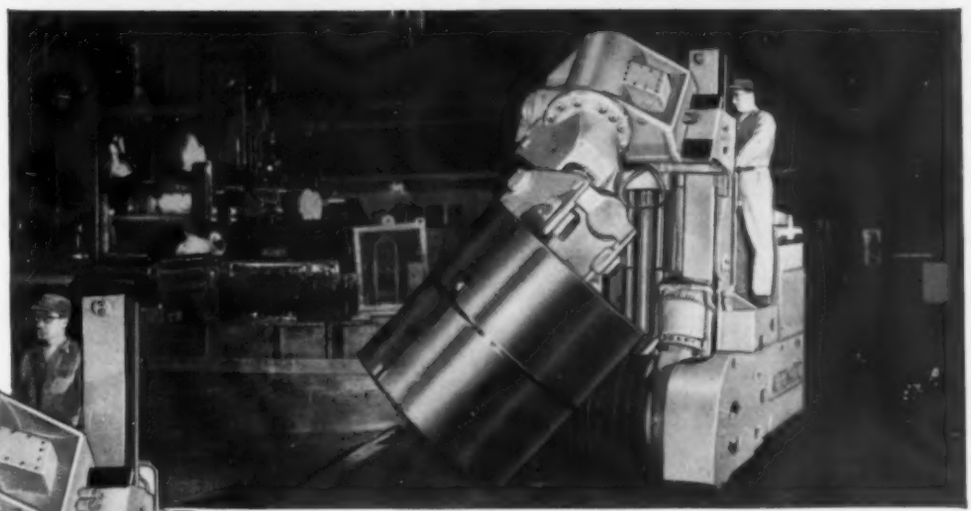
▲ Exclusive rights have been granted to Thermal Research & Engineering Corp. to manufacture and sell high intensity combustion devices developed and patented by the Lummus Co.

The equipment involved in the licensing agreement centers about a patented Lummus combustion device which provides high intensity, clean combustion with all grades of refinery gas and petroleum products. It is especially effective in the very large heat producing capacities above 10 million Btu per hour and with the use of residual fuels, including tar and asphalt. The Lummus design complements Thermal's own line of burners which are at present espe-

New Automatic Attachment is COIL UP-ENDER AND RAM IN ONE!

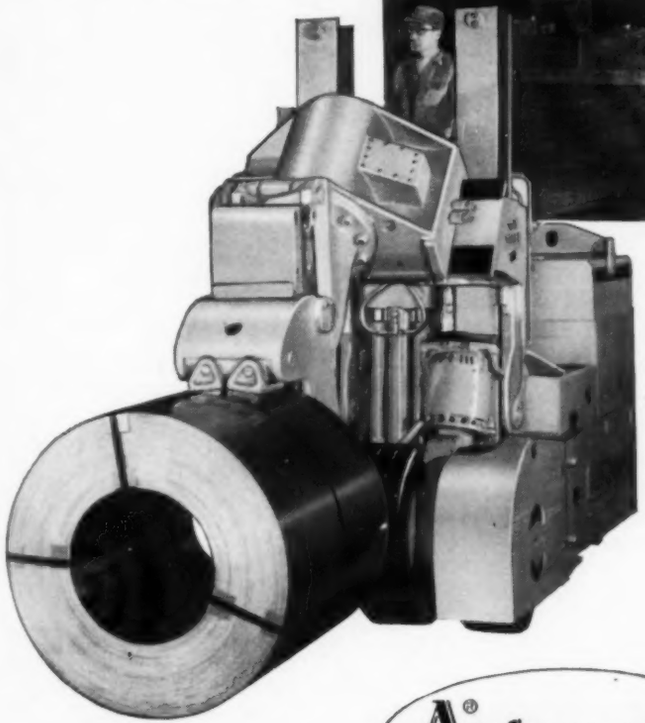
1.

Picks up coil in vertical position and rotates to horizontal or vice versa... handles up to 60,000 lb. coil.



2.

Holds coil securely throughout rotation...prevents telescoping...no distortion, no damage to coil ends.



3.

Transports coil in any position; can be replaced by forks or ram for other uses.

Only Automatic Has It!

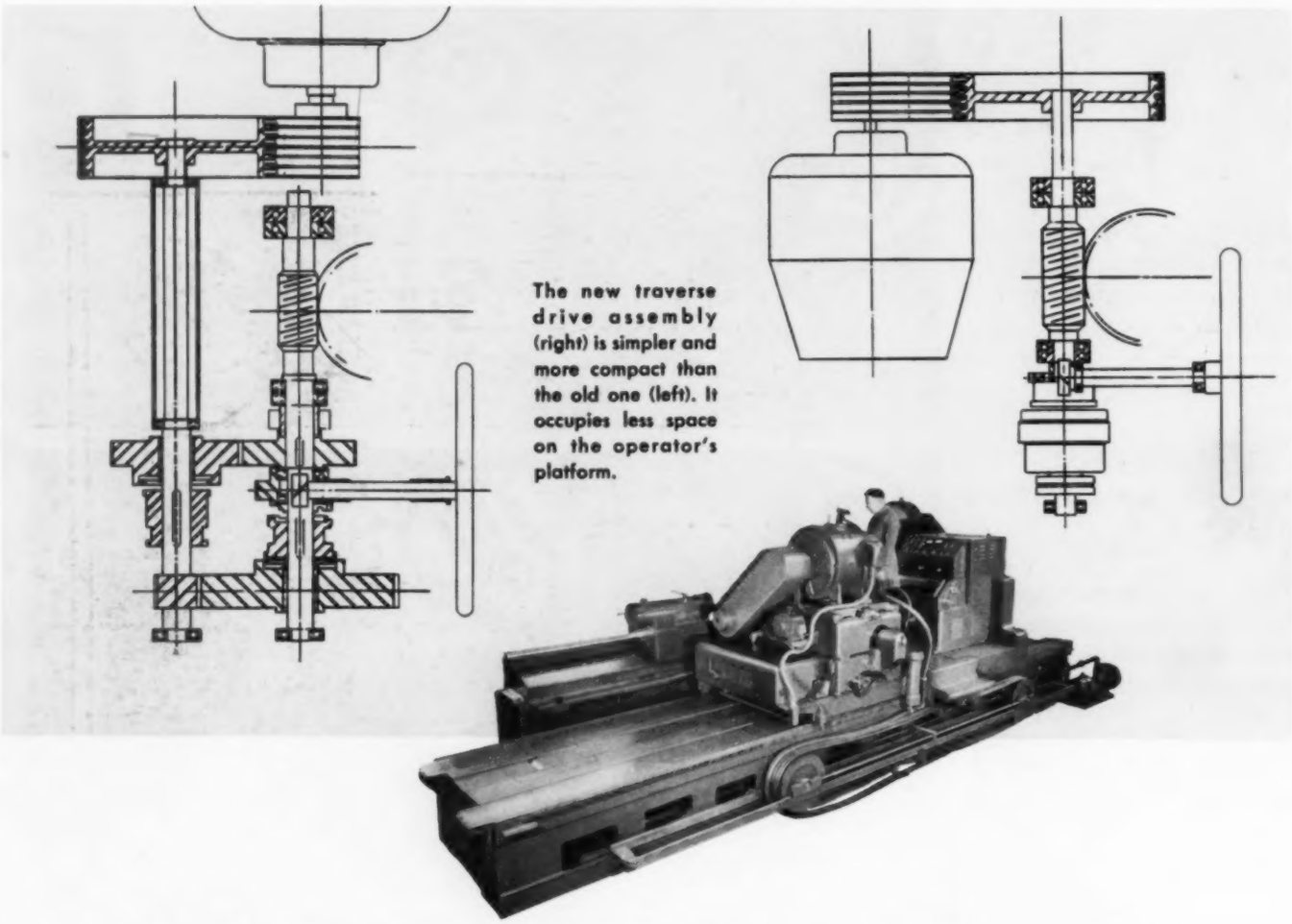
Another important "first" for Automatic engineering...this attachment eliminates the necessity for separate up-ending units in handling steel coils weighing up to 60,000 lbs. Flexibility in handling and storage is substantially improved and usefulness of the heavy duty ram truck is correspondingly increased. The coil is held securely, at any stage of rotation with a minimum of pressure, eliminating damage to coils.

This unit is now available on the new Automatic HR Series electric trucks or as an attachment for any Automatic truck of suitable design and capacity. Write today for further information.

Automatic
47 West 87th Street
Chicago 20, Illinois, Dept M-6

WORLD'S LARGEST EXCLUSIVE BUILDER OF ELECTRIC-DRIVEN INDUSTRIAL TRUCKS

Meet a solid reason why Farrel® H-D roll grinders are better than ever



The new traverse drive assembly (right) is simpler and more compact than the old one (left). It occupies less space on the operator's platform.

Accurate, fast, economical and easy to handle—that's the reputation of Farrel heavy duty roll grinders. And now . . . with the addition of a number of significant design improvements . . . overall performance of these popular machines is even better.

Take the new carriage traverse drive, for example. It is an adjustable-speed, packaged power unit, with the entire speed range governed by a rheostat. Speed-change gears and clutches, which were previously required, have been eliminated.

This simplified design improves operating control of the traverse; also reduces maintenance. What's more, the cabinet for the new drive is considerably smaller, giving the operator more space on the platform.

Write for full details of this and other features of the improved Farrel HD grinder.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT
Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Akron, Chicago, Fayetteville (N. C.), Los Angeles, Houston

FARREL METALWORKING MACHINERY

Rolls • Rolling Mills • Slab, Rod and Strip Handling Equipment • Roller Tables • Rod Coilers • Slitters • Gears • Gear Drives of Any Capacity • Mill Pinions • Pinion Stands • Universal Mill Spindles • Flexible Couplings • Roll Grinding Machines • Roll Calipers • Hydraulic Presses for Extruding, Forming, Drawing, Forging, Trimming, Hobbing, Straightening and Bending.

Farrel-Birmingham®

FB-1085

cially developed for gas and distillate type oils and are available in sizes up to approximately 10 million Btu per hour.

The licensing agreement calls for an initial cash payment to Lummus by Thermal and an annual royalty based upon a per cent of sales. Thermal plans also to develop further the Lummus equipment for many new applications including chemical burning.

H. K. PORTER ACQUIRES ELECTRIC SERVICE MFG.

▲ Electric Service Manufacturing Co. has been acquired by H. K. Porter Co., Inc., according to an announcement by T. M. Evans, Porter's president. Mr. Evans stated that R. Kreinberg, president of Electric Service, and others of the management staff, will continue with the new Porter unit.

Electric Service's main office and plant are located at 17th and Cambria Streets, Philadelphia. Sales offices are in New York, Pittsburgh, Chicago, St. Louis, Birmingham, Dallas and Cleveland.

LOFTUS ENGINEERING AWARDED NAVY CONTRACT

▲ Loftus Engineering Corp. of Pittsburgh, Pa., was the successful low bidder for the procurement and installation of a car bottom furnace at the Naval Air Material Center, Philadelphia, Pa. This contract is under the administrative and technical control of the officer in charge of construction, Bureau of Yards and Dock Contracts, Fourth Naval District, U. S. Naval Base, Philadelphia, Pa.

The work includes design and construction of a 2000 F gas-fired furnace complete with track and foundation, ready to operate. The contract also includes incidental related work.

MESTA TO BUILD HOT STRIP MILL AT ALIQUIPPA

▲ A contract to furnish a 44 in. semi-continuous hot strip mill at the Aliquippa Works of Jones and Laughlin Steel Corp. has been awarded to Mesta Machine Co. The installation will be arranged to roll steel either directly from ingots rolled on the slabbing-blooming mill or from reheated slabs.

TIMKEN Company ORDERS 2 MORE DIAMOND ITV UNITS

(WIRED TELEVISION)

AFTER 3 SUCCESSFUL INSTALLATIONS

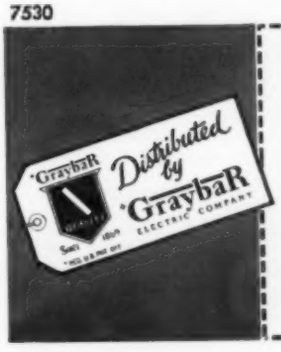
Picture of furnace interior on Diamond ITV viewing screen is watched by remote dispatcher. A flip of a switch and he SEES conditions in another furnace on same screen.

Operator at another control pulpit SEES a visually inaccessible billet loading area for a pusher type furnace.

The Timken Roller Bearing Company made its first application of Diamond Industrial TV in August 1951 for remote observation of the interior of a tube-cooling furnace. Since that time two additional installations have been made to watch (1) the inside of another furnace and (2) the remote handling of billets by a crane. The success of these has resulted in a recent order for two more sets of Diamond ITV.

You, too, probably can use Diamond ITV to substantial advantage. Call your Graybar Distributor or use the coupon below.

7530



DIAMOND POWER SPECIALTY CORP.
"FIRST IN INDUSTRIAL TELEVISION"
ELECTRONICS DEPT., P. O. BOX 56FF
LANCASTER, OHIO

Please send me without obligation a copy of new bulletin showing how Diamond Industrial (Wired) Television will help me reduce costs, improve quality, increase sales and aid safety.

Name_____

Title_____

Company_____

Address_____

The mechanical equipment will include a new slab and bloom shear installed in the slabbing mill department, alterations to the bar and billet mill transfer and tables, hot strip mill universal reversing roughing stand, rotary crop shear, scale breaking stand, vertical edging mills, six hot strip mill finishing stands, downcoilers, with transfers, pilers, unpilers, and conveying tables.

The new strip mill will be designed to hot roll steel up to 38 in. wide to be delivered to the five-stand tandem cold mill for cold rolling into tin plate stock. The new mill will also roll hot strip for fabrication of electrical welded pipe, skelp for continuous butt welded pipe and barrel stock.

Mesta will design the complete installation, will make all engineering detail drawings for field construction, mechanical and electrical equipment, and be responsible for their installation.

HEWITT-ROBINS GIVEN CONVEYOR CONTRACT

▲A contract amounting to more than $1,000,000 for a conveyor system to be installed in United States Steel Corp.'s new ore screening and sintering plant at Youngstown, Ohio, has been awarded to Hewitt-Robins, Inc.

The conveyor system will consist of 40 separate units totaling more than 7100 ft in length. Installation will be completed early in 1957.

The new ore screening and sintering plant will process iron ore shipped to the Youngstown plant via railroad car. Conveyors will transfer the ore from a Wellman rotor car dumper to the plant at a rate of 3000 tons per hour.

SAVE downtime for bearing replacement

use A·B·K* bearings

A-B-K bearings won't peen, score or heat check your heavy roll and spindle parts, sharply reduce downtime and maintenance costs per ton rolled. Made of laminated phenolic fabric, they have the ability to absorb and cushion heavier impacts—and often outwear metal bearings many times. When replacements *are* necessary, downtime is reduced because A-B-K bearings have fewer parts, are lighter in weight, easier to handle. Ask our engineers for specific recommendations.

- Wear longer
- Won't score
- Light in weight
- Cut lubricant costs
- Save power

A·B·K
LAMINATED
PHENOLIC BEARINGS

*A registered trade-mark of American Brake Shoe Company in the United States and of Joseph Robb & Company, Limited, in Canada.

Brake Shoe
AMERICAN BRAKEBLOK DIVISION
Detroit 9, Michigan
In Canada: Joseph Robb & Co., Ltd., Montreal, Quebec

ANNOUNCES COMPLETION OF RENOVATION PROGRAM

▲ York-Gillespie Manufacturing Co. recently completed a major renovation program, which has quadrupled its capacity.

Acquisition of an adjacent building, afforded the firm over 40,000 sq ft of active shop area. In addition, York-Gillespie replaced all its plant equipment with direct-drive, rapid traverse, high-speed equipment.

The entire operational area has been rearranged, resulting in more room for fabricating, assembling and storing.

WEST COAST COMPANY ACQUIRED BY I-T-E

▲ I-T-E Circuit Breaker Co. has acquired all capital stock of Kellman Electric & Manufacturing Co. of Los Angeles, Calif., through an exchange of I-T-E common stock with founders and owners of that company.

Kelman manufactures high voltage circuit breakers, rated from 7.2 kv to 220 kv with interrupting ratings to 10 million kva, used in the transmission and distribution of electric power. These products complement those of I-T-E.

Kelman will continue the manufacturing and marketing of its products on the west coast and will operate as a subsidiary of I-T-E.

Meetings

The 19th annual American Power Conference, sponsored by Illinois Institute of Technology, in cooperation with 14 universities and nine technical societies, will be held at Hotel Sherman, Chicago, Ill., March 27-29, 1957.

here's why LINE-ARC contactors are industry's first choice

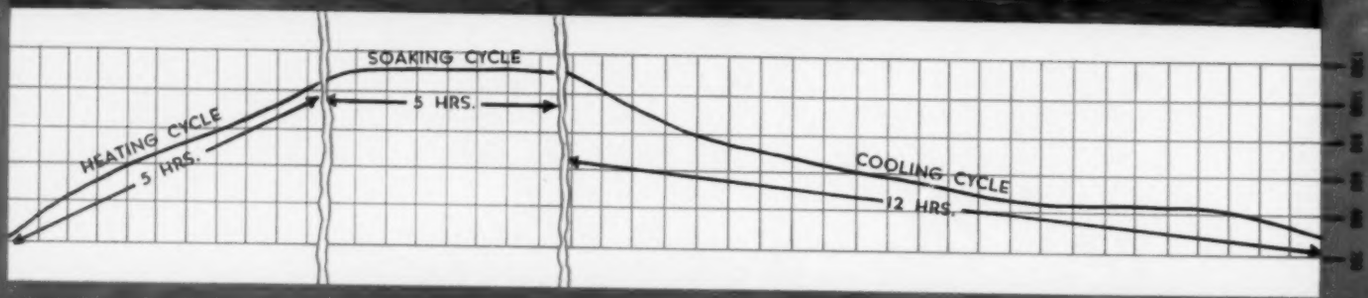
No Destructive Arc Shield Burning
Arc is a line centered between, but not touching, the arc shields.
Quick Removal of Hot-Arc From Contacts
No Lubrication-Maintenance
Self-lubricating bearings on main and auxiliary arms eliminate often overlooked lubrication-maintenance.
Magnetic Dust Problem is Licked
Safer Electrical Interlocking

These Contactors are a tribute to sound engineering design. They have proved themselves in the severest crane and mill service. They respond quickly, due to the light-weight arm construction, handle the arc scientifically, and have long life. The high efficiency and lower upkeep of EC&M *"LINE-ARC"* Contactors are good reasons for specifying EC&M Magnetic Control for Cranes and auxiliary mill drives.

Write for Bulletin 1145-E.

SQUARE D COMPANY

EC & M DIVISION . CLEVELAND 28, OHIO



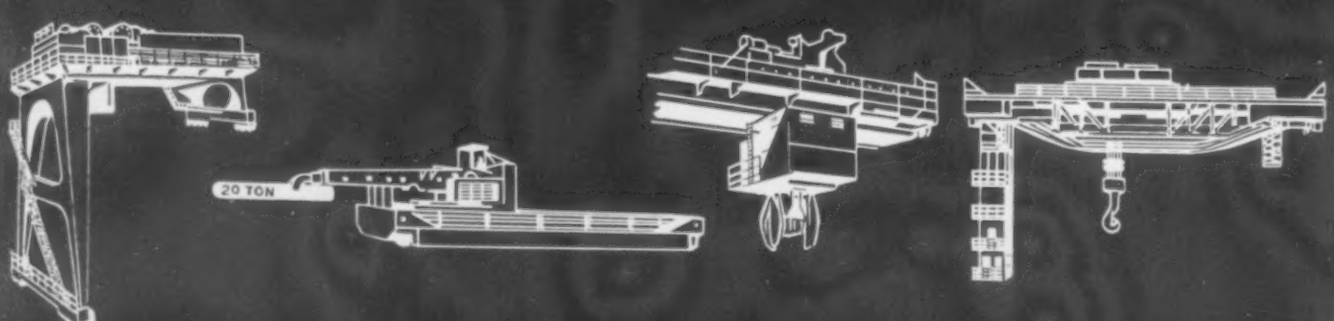
TROLLEY FRAME BY *Alliance*
STRESS RELIEF BY BLISS

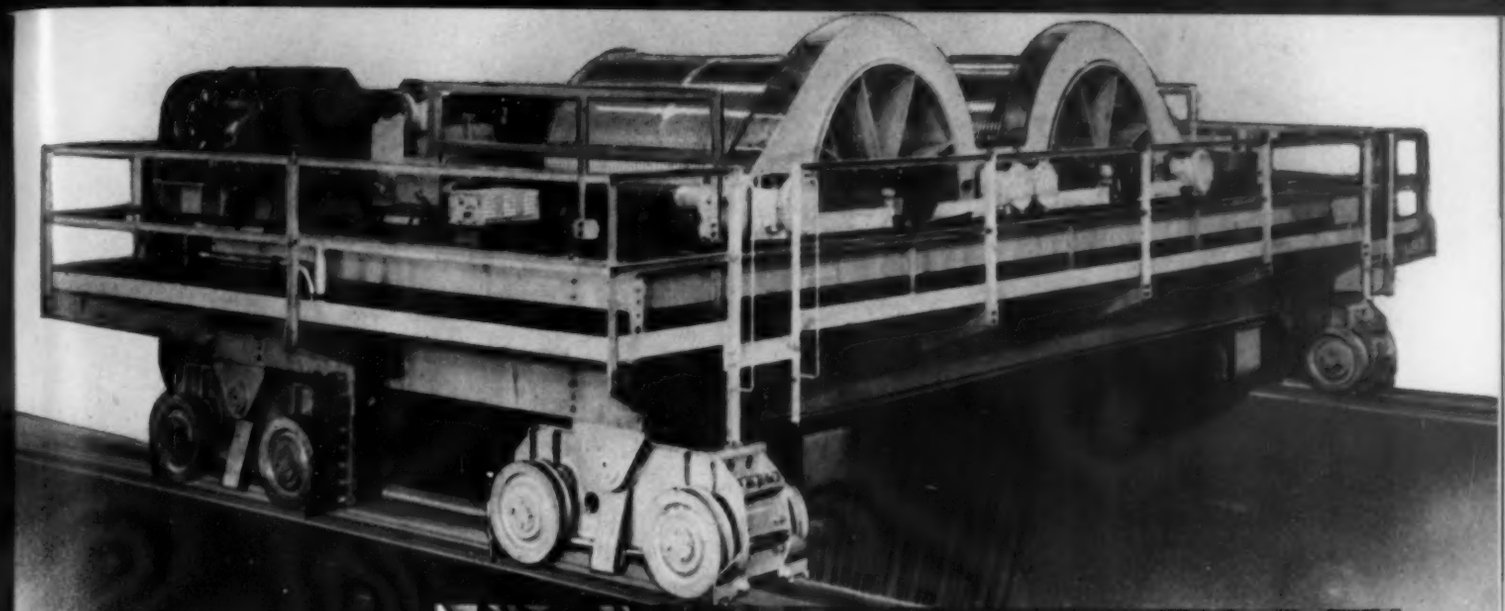
● The trolley pictured above is part of an Alliance crane rated at 450-tons' capacity. It's BIG! The trolley rolls smoothly on 16 track wheels arranged to provide transverse and longitudinal equalization. It will give longer, safer service because it has been accurately stress relieved. Since 1946 every trolley frame built by Alliance has been stress relieved by the E. W. Bliss Company— a leader in the design and production of rolling mill equipment.

The heat control chart is a reproduction of the chart used in stress relieving the frame shown above. The heating cycle is long; the soaking cycle is one hour at 1175° for each inch of thickness in the heaviest member.

Quality control extends through every phase of Alliance operations—design, engineering and production—including the use of outside help when necessary.

Before you start your expansion program discuss your lifting needs with the Alliance engineers. They'll help you reach an efficient, economical solution.





TROLLEY FOR THE WORLD'S BIGGEST CRANE BY.....

Alliance 450-ton, 4-girder, 60-foot span ladle crane handles 610-ton test load.

THE *Alliance* MACHINE COMPANY

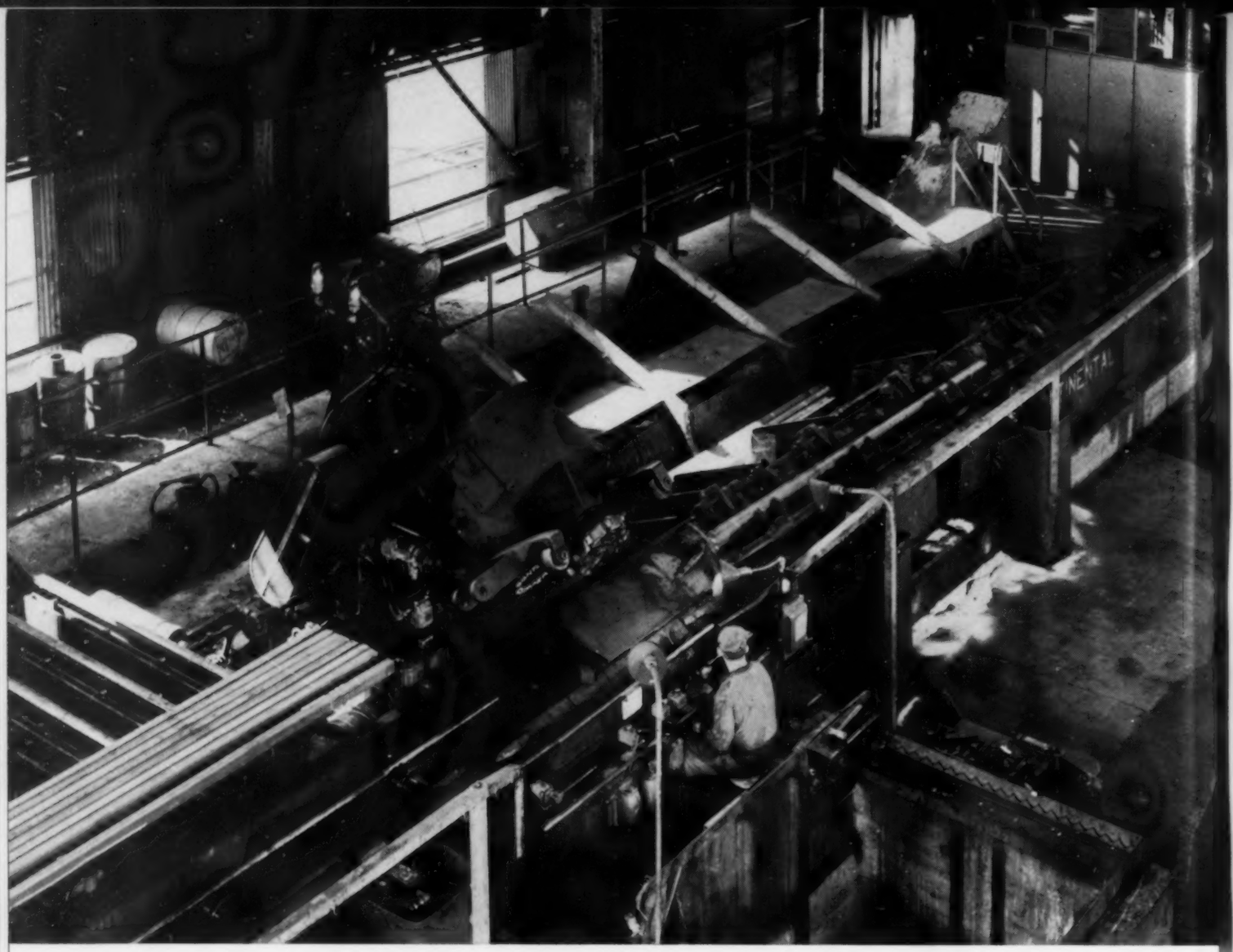
FOUNDED 1901

MAIN OFFICE ALLIANCE, OHIO

World's largest builders of world's largest cranes

Manufacturers of:

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION • COKE PUSHERS • ORE BRIDGES • SHEET CARRIERS



BLAW-KNOX makes what it takes

for continuous, mechanical chipping

The Continental Chipper with auxiliary equipment is a complete mechanical system for sorting, handling, inspecting and chipping billets. This integrated system has demonstrated in-service cost savings over manual conditioning. It represents a wise investment in long range modernization programs for conditioning for subsequent rolling in merchant and bar mill operations.

Product quality improvement is immediate, positive. Precise chipping is accomplished by a non-traveling cutter head under which the billet moves in a fashion similar to a milling machine. All chipping is done at close range, immediately in front of the operator. This single operator, located in front of the cutter head controls the entire operation including all material handling.

The chipper is equipped with special interlocking devices which eliminate unsafe operation. Usual chipping bay hazards such as high pressure air lines, improperly handled chisels, and flying chips are removed. The Continental Chipper accommodates billets up to 30 feet in all merchant and bar mill sizes.

For complete details, write for illustrated booklet.

50th Anniversary
BLAW-KNOX
1906-1956

BLAW-KNOX COMPANY
Foundry and Mill Machinery Division
Blaw-Knox Building • 300 Sixth Avenue
Pittsburgh 22, Pennsylvania

CONTINENTAL

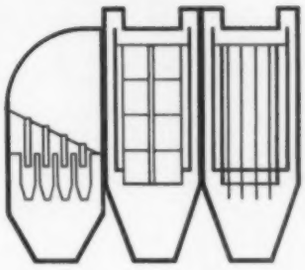
The industry's most experienced organization in dust, fume and fly ash recovery

—as near as your telephone!

Because the Western Precipitation Corporation stands alone in its years of continuous leadership in the complex science of recovering suspensions from industrial gases, Western Precipitation installations, quite naturally, are recognized throughout the world as the best obtainable. . .

■ Almost a half-century ago—in 1907 to be exact—Western Precipitation installed the first commercial application of the now-famous Cottrell Electrical Precipitator—and has more know-how, more varied experience and application background in world-wide installations in this type of equipment than any other organization, domestic or foreign.

■ Many years ago Western Precipitation was first again with the multiple small-diameter tube type of cyclonic collector—the type with higher centrifugal forces for greater recovery efficiencies. And through the years, Western Precipitation engineers have continuously led in new advancements, new refinements in the *mechanical* recovery field as well as in *electrical* recovery methods.



■ Western Precipitation was the first to combine Electrical and Mechanical recovery advantages in one compact, coordinated system—the CMP (Combination Multiclone—Precipitator) Unit. This equipment, offering almost constant collection efficiency despite varying gas volume, requires years of experience in both electrical and mechanical recovery methods for proper operating "balance".

. . . only Western Precipitation has had such extensive experience in basic recovery methods!

These are only a few of the many important reasons why a Western Precipitation installation is recognized as the best obtainable. This unequalled know-how is quickly available throughout the major industrial areas of the United States and Canada from strategically-located, fully-staffed offices and field representatives, as shown at right. There's one as near as your telephone.
So before you finalize any dust, fume or fly ash recovery plans, be sure to find out the vital *extra* advantages offered by Western Precipitation Corporation!

For literature describing Western Precipitation's unique background of experience and advancements, phone, wire or write our nearest office.

wp

COTTRELL Electrical Precipitators
MULTICLONE Mechanical Collectors
CMP Combination Units
DUALAIRE Reverse-Jet Filters
HOLO-FLITE Processors

Western Precipitation Corporation

Designers and Manufacturers of Equipment for Collection of Suspended Material from Gases . . . and Equipment for the Process Industries

Main Offices **1067 WEST NINTH STREET, LOS ANGELES 15, CALIFORNIA**

Chrysler Building, New York 17 • 1 North La Salle Street Building, Chicago 2 • Oliver Building, Pittsburgh 22 • 3252 Peachtree Road N. E., Atlanta 5 • Hobart Building, San Francisco 4

Precipitation Company of Canada Ltd., Dominion Square Building, Montreal
Representatives in all principal cities

TORRINGTON *CUSTOM-MADE* BEARINGS

"This 63" bearing was custom-made for us—by TORRINGTON!"

Building custom bearings for industry is a Torrington specialty. Whatever the anti-friction assignment—Torrington can design and build the bearing for the job.

When you specify a Torrington job-designed bearing, you're calling on engineers with extensive experience in custom-bearing applications. Torrington will survey your needs, recommend and design the right bearing to provide peak efficiency, economy and service life.

For *any* standard or custom bearing, backed by broad manufacturing and design experience—specify TORRINGTON.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

90th ANNIVERSARY 1866-1956

TORRINGTON BEARINGS

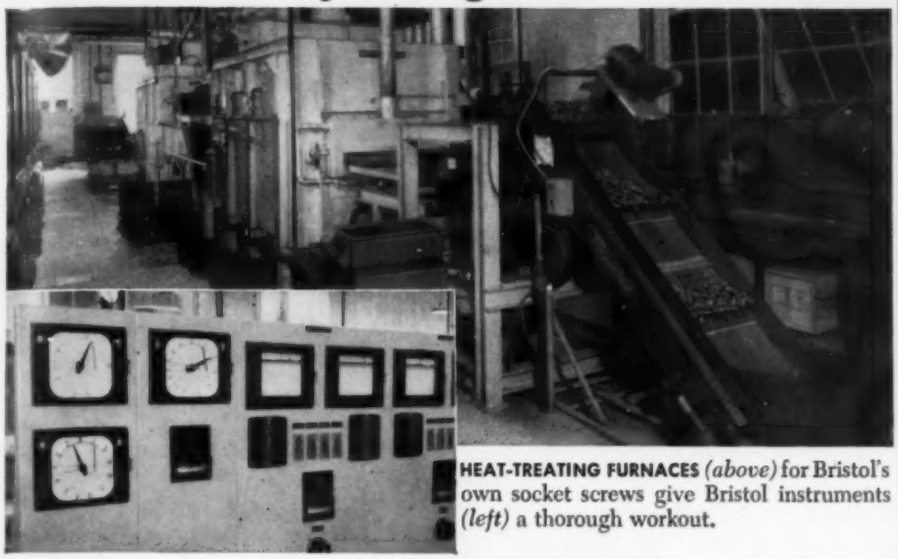
Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers

BRISTOL'S

Instrumentation News

• *News of instrumentation and automatic control in industrial heating and metallurgy* •

New instruments pass tough "field" tests at home



HEAT-TREATING FURNACES *(above)* for Bristol's own socket screws give Bristol instruments *(left)* a thorough workout.

New Bristol instruments for metal-treating operations have a ready-made proving ground in Bristol's own socket screw manufacturing division.

Bristol instruments monitor and automatically control every phase of the Socket Screw Division's metal treatment—including a variety of continuous and batch-type furnaces, salt-baths, and tinning and degreasing operations for specialty products.

Completely automatic control assures highest quality and uniformity for Bristol socket screw products. New instruments get grueling "field" tests before they're released for general distribution. And, last but not least, visitors to the Waterbury plant can see Bristol instruments under actual load conditions.

Drop in, when you're in the New England area, and watch these precision instruments at work!

New control techniques cut fuel bills for metals

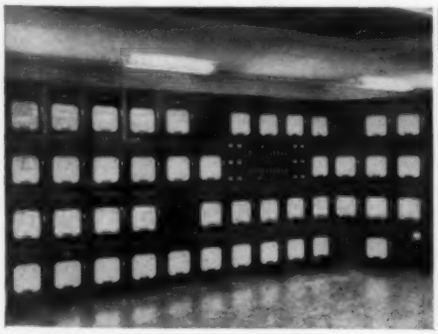
In 20 years, fuel required for ingot heating has dropped 50 to 60%.

A big share of the credit for this fuel economy goes to automatic control and instrumentation techniques developed recently. These new techniques, with better, faster, more accurate sensing and response, have chalked up significant savings, not only in fuel, but also in fixed charges, rolling time, and maintenance costs.

Probably most important for big savings is control of furnace temperature and atmosphere. Furnace pressure may be regulated by positioning the stack damper. Fuel-air ratio can be controlled by a valve in the air line. Air requirements for combined fuels may be totalized for better distribution of fuel throughout the plant.

Proper temperature-time sequences or "time cycles" also rack up big savings. Step heating sequences, differing for various metal ingots, no longer need be programmed by rule of thumb. Instead, any predetermined sequence of temperatures can be maintained automatically and easily changed to suit particular batches.

THESE BRISTOL ELECTRONIC AND AIR-OPERATED pyrometers automatically control regenerative soaking pits. Platinum, platinum-rhodium thermocouples at pit covers are sensing elements.



Telemetering helps control steel plant fuel

This Bristol telemetering installation helps U. S. Steel, Gary, Indiana, get the highest steel production with the lowest possible fuel cost.

The panel shows the amount of coke-oven and blast-furnace gas used throughout the plant as well as gas pressures at critical locations. With this complete supply and demand information at their fingertips, fuel dispatchers can control distribution for maximum efficiency and economy.

Precision rolling mill produces steel tapes 0.000125" thick

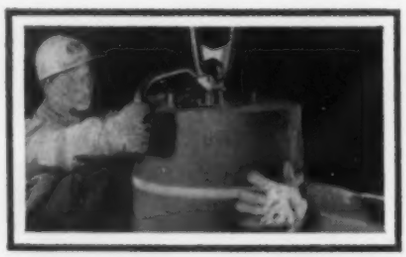
This precision cold-strip mill at The Arnold Engineering Company, Marengo, Illinois, rolls ultra-thin high-permeability strips for magnetic cores. The core strips may be as thin as 0.000125" and must be held to extremely close tolerances. To achieve the necessary precision, AccuRay gauges—employing Bristol Dynamaster recorders—measure thickness of material on both sides of the rolling mill. The AccuRay equipment is built by Industrial Nucleonics, Columbus, Ohio.

Want to apply these up-to-date control and instrumentation techniques to your industrial heating problem? Bristol engineers will be glad to talk over specific processes, problems, facts and figures with you. Write today to The Bristol Company, 123 Bristol Road, Waterbury, Conn.

BRISTOL *POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

MAKE A DATE WITH SAVINGS...



Arrange for your men to see and hear

National Carbon's

new electrode shop training program

Here's a must for operating, supervisory, purchasing and management personnel . . . any one concerned with the procurement, storage, handling or use of electrodes. It's available free — in your own plant or any other mutually convenient location. Thorough coverage of the manufacturer's recommendations for proper electrode usage . . . illustration and demonstration drive home the fundamentals of good electrode practice . . . help you get top value from every electrode dollar.

- Product quality recognized to be the highest in the industry.
- New end-caps — protect sockets from dust, dirt and end-face chipping.
- New pin package — quicker identification, easier handling and storage.
- Complete technical service — designed to extend the service normally provided by field salesmen.

Write or call right now for complete details of the new electrode training program and arrange to have this important educational demonstration put on for your personnel.

For Electrodes and Electrode Service . . . rely on National Carbon Company

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY . A Division of Union Carbide and Carbon Corporation

30 East 42nd Street, New York 17, N. Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco
In Canada: Union Carbide Canada Limited, Toronto

Personnel News...

Frank O. Phillips has been appointed assistant to vice president-steel of United States Steel Corp. with responsibility for maintenance planning. Mr. Phillips was first employed by U. S. Steel as an electrician at Gary Sheet and Tin Works in 1935. In 1937 he was transferred to Irvin Works as power foreman. He went to Vandergrift in 1940 as assistant chief electrician. Transferred to Homestead in 1941, Mr. Phillips advanced to assistant superintendent of the 100-in. semi-continuous mill in 1949. In 1950 he became superintendent of Homestead's 45-in. mill and in June, 1951, he was made division superintendent of maintenance of Duquesne Works, the position he held at the time of his present appointment.

Julius H. Clabaugh, formerly manager of the Quality Control Department of Copperweld Steel Co.'s Ohio Seamless Tube Division, has been made assistant manager of operations. **Donald R. Chew** has been appointed to head Quality Control. **Francis S. Coleman,** assistant chief engineer for several years, has been appointed chief engineer. **George P. Jones** moves up from his position as chief draftsman to assistant chief engineer.

Harry W. Finney was appointed division superintendent of the Saxonburg plant of United States Steel Corp. In his new assignment, Mr. Finney will be in charge of U. S. Steel's new sintering plant now under initial construction. He was first employed by U. S. Steel in 1940, at Duquesne Works where he started his steel career as a practice apprentice. In 1947 he became assistant to superintendent, blast furnace department. He remained at Duquesne until 1948 when he was transferred to Edgar Thomson Works as general foreman, auxiliary. In April of the following year he was appointed assistant superintendent, blast furnace department, the position he held prior to his new appointment.

Donald B. Gillies has fully retired from active service after almost 50 years of active service with Republic Steel Corp. and predecessor companies. Mr. Gillies was a vice president of Republic Steel until his 75th birthday in 1947 when he was relieved of his responsibilities as an officer of the company but continued a full and active business life as a mining consultant for Republic.

Fred H. Johnson, after 43 years' service as an engineer in the steel industry, retired from Inland Steel Co. on August 1. He had been chief engineer of the company's Indiana Harbor Works from 1949 until 1955, when he became assistant to the vice president in charge of planning and administration. Mr. Johnson came to Inland as chief engineer in 1949 from United States Steel Corp., where he had been assistant chief engineer of its Chicago district. Prior to joining U. S. Steel, he was assistant chief engineer of the Interlake Iron Corp. He started his career in the steel industry as a draftsman with the Minnesota Steel Co. in Duluth, Minn. in 1913.

Leonard J. Spivak has been named superintendent of Republic Steel Corp.'s Roll Shop at Gadsden, Ala. He succeeds **A. E. Pratt** who recently retired.

Robert E. Williams has been appointed director of distribution and availability of United States Steel Corp. Mr. Williams was previously with the Columbia-Geneva Steel Division of U. S. Steel where he had been assistant vice president—sales. He succeeds **M. D. Millard,** who was recently made general manager of sales of the American Steel and Wire Division of the corporation.

Glenn B. Miller was named traffic manager of Crucible Steel Co. of America, and **Daniel G. Donovan** was named assistant traffic manager.

Robert J. Stock was made staff assistant to the vice president-engineering, Allegheny Ludlum Steel Corp., Brackenridge, Pa. He is succeeded as works manager at the Watervliet, N. Y., works by **Arthur F. Schraeder,** former assistant manager of maintenance.

John K. Deasy has been named assistant vice president purchasing and traffic for Weirton Steel Co. Mr. Deasy was previously general traffic manager.

Dr. Eric R. Morgan formerly with the Ford Motor Co., has joined Jones & Laughlin Steel Corp.'s staff as assistant director of research with supervision of process and physical metallurgy, analytical chemistry, and coatings and corrosion research. **Dwight C. Brown** has

FRANK O. PHILLIPS

JULIUS H. CLABAUGH

FRANCIS S. COLEMAN

HARRY W. FINNEY

DR. ERIC R. MORGAN

MAYNARD W. JOHNSON

ROBERT J. LINNEY

GEORGE E. BRUMBA

been promoted to assistant director of research with supervision of research on coal chemicals and ore. He will continue to direct Chemical Engineering Services, which will be transferred to the Research Division. **Richard R. Webster** has been promoted to assistant director of research with supervision of instrument development and application of instrumentation to process control.

Maynard W. Johnson, manager for three years of the Oakland, Calif., plant of the General Electric Co.'s Distribution Transformer Department, has been appointed general manager of the Large Motor and Generator Department at Schenectady, N. Y. Mr. Johnson replaces **Joseph F. Eckel.**

Robert J. Linney was named vice president in charge of operations of Reserve Mining Co. Mr. Linney has been manager of operations for Reserve since he joined the company at Babbitt, Minn., in 1950.

George E. Brumbach has been appointed chief metallurgist of the Carpenter Steel Co. He succeeds **Dr. Carl B. Post,** now vice president and technical director of the company.

A. Murray McLean was appointed works manager, Vanadium-Alloys Steel Canada, Ltd., London, Ont., Canada. He was formerly with Atlas Steels, Ltd. for 14 years.

Kenneth N. Bundy was made assistant superintendent of Wheeling Steel Corp.'s by-product coke plant, Steubenville, Ohio.

T. O. Zittel succeeds **R. W. Graham,** retired, as superintendent, electrical department, at Bethlehem Steel Co.'s Lackawanna, N. Y., plant. **C. L. Squier** succeeds Mr. Zittel as assistant superintendent.

Gordon M. Piotrowski has been named a district application engineer in the Chicago District Office of the Clark Controller Co.

Karl H. Kostenbader, Sr. was made superintendent of foundries at Bethlehem Steel Co.'s Bethlehem, Pa., plant. He succeeds **Clarence A. Bever,** retired. **Jesse H. Muir** succeeds Mr. Kostenbader as superintendent of the steel foundry. **James C. McKerihan** becomes assistant superintendent steel foundry; and **John B. Stevens,** assistant superintendent, iron foundry.

John E. Stukel joined the ore sales department of Cleveland-Cliffs Iron Co., Cleveland, as metallurgical sales engineer. He was formerly with Youngstown Sheet & Tube Co.

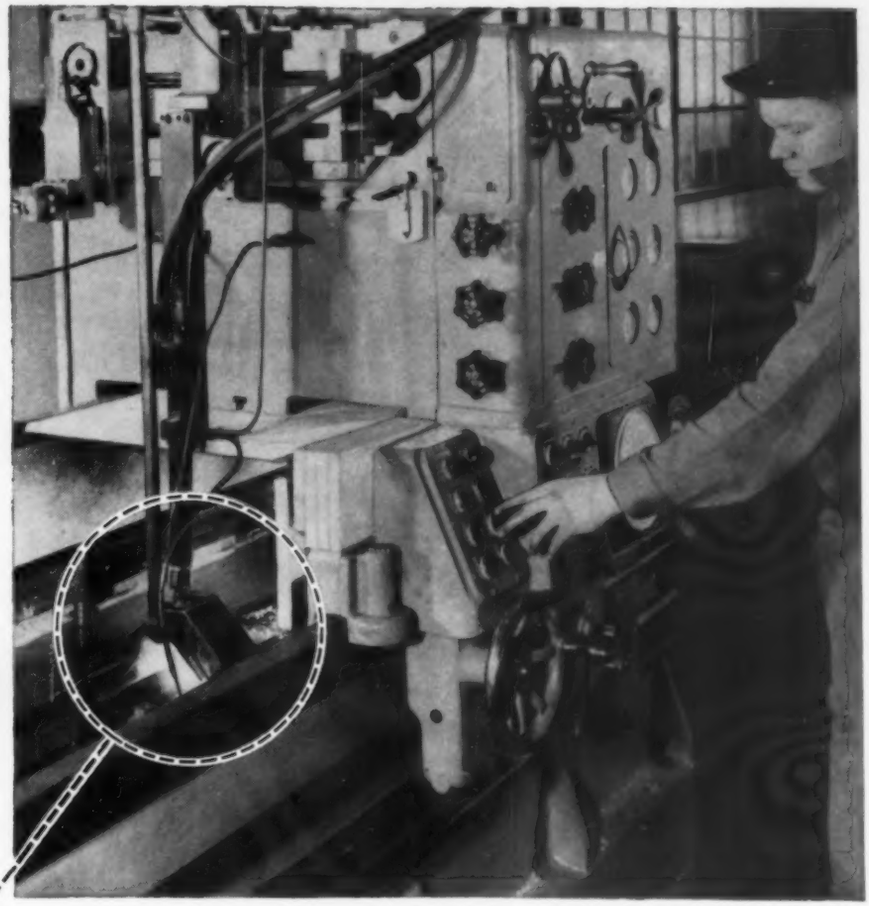
Ellis A. Trautman has been appointed general manager of Mesta Machine Co.'s New Castle plant. Assisting Mr. Trautman as manufacturing manager will be **Leonard F. Quinn.**

ELLIS A. TRAUTMAN

Roger K. Furse has joined Universal-Cyclops Steel Corp. as superintendent of the company's Cold Finishing Department. He was formerly employed at Copperweld Steel Co. as development engineer, and for the last three years as superintendent of hot and cold rolling at the Blairsville plant of Westinghouse Electric Corp.

Charles E. Brackbill has been appointed executive staff assistant in production for the Laclede-Christy Co. Division, H. K. Porter Co., Inc.

HIGH SPEED FLAME-HARDENING



Cross-section view shows uniform depth of hardened surface.

SPECIAL MACHINE UPS LIFE OF GRAPHITIC STEEL PARTS

LINDE engineers have assisted Cincinnati Steel Treating Company in developing a flame hardening machine which increases service life of 16 ft. long, graphitic carbon steel lathe ways . . . Development of this automatic, high speed machine is another example of how LINDE Service Engineers are helping LINDE's customers up production speed and unit quality through co-operative research engineering.

With this new machine, a lathe way to be treated is placed on a magnetic chuck in a water filled channel. Flame-hardening heads and control mechanism move at predetermined speeds along the part. After it cools, the lathe way is placed in a refrigerator for 24 hours which stabilizes the steel, and brings its case hardness to a minimum of 60 Rockwell "C" scale.

The benefits of LINDE's research, engineering, and over 40 years of accumulated know-how stand behind each of its customers to help them solve production problems. Get these "plus-values" which LINDE offers—it pays you to do business with LINDE.

Linde Air Products Company
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
Offices in Other Principal Cities
In Canada: LINDE AIR PRODUCTS COMPANY
Division of Union Carbide Canada Limited, Toronto

The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.

Linde
Trade-Mark

Robert L. Stockus has been named manager, rolling mill sales Farrel-Birmingham Co., Inc., He succeeds **George F. Schaefer** who has retired after thirty-one years with the company. Mr. Stockus came to Farrel-Birmingham as assistant manager of the rolling mill division in 1953. Prior to this he was sales manager of Armzen Co. Also announced was the appointment of **Howard E. Kuehn** as division engineer, rolling mills.

H. R. Loxterman was advanced to general sales manager, and **Edward W. Pottmeyer** to manager of engineering and development of the Blaw-Knox Equipment Division, Blaw-Knox Co. Mr. Loxterman succeeds **Arthur A. Levison,** who has been assigned to the headquarters staff of **E. C. Rook,** vice president—general manager of the Fabricated Products Group. Mr. Loxterman has been associated with Blaw-Knox since 1930 and has been assistant general sales manager of the division since 1952. In addition to his new post he will continue as sales manager for steel plant equipment. Mr. Pottmeyer succeeds **A. H. Jackson,** who recently was advanced to general manager of the division. Mr. Pottmeyer was formerly chief product engineer of the Steel Plant Equipment department and has served in a variety of engineering capacities since joining the company in 1927.

Irving M. Oppenheim has been named superintendent of the Electrical Department by Universal-Cyclops Steel Corp. He was formerly assistant chief electrician at the Pittsburgh Works of Jones and Laughlin Steel Corp. It was also announced that **Michael J. Shepos,** former electrical superintendent, will assume a newly created position as staff engineer, electrical.

John P. Cawley has been appointed supervisor of job training programs for Republic Steel Corp. He has been succeeded as supervisor of training at Republic's Cleveland steel plant by **Chris A. DeJohn,** formerly assistant supervisor of training.

W. E. "Bill" Thomas has been appointed regional manager for the valve division of Homestead Valve Manufacturing Co. He will make his headquarters at 805 Church Street, Decatur, Ga.

Dr. Robert K. Smith has been appointed manager of research for E. F. Houghton & Co. Before joining Houghton, Dr. Smith was associated with Houdry Process Corp., Kendall Refining, and the Standard Oil Development Co.

Bernhard W. Weber has been named to head manufacturing operations of Metal & Thermit Corp., with the title of manager of manufacturing. He succeeds **Walton S. Smith** who recently retired as vice president in charge of manufacturing. **H. Alfred Rack,** formerly manager of engineering, will take over Mr. Weber's former post as production manager.

Fred Knight, western sales manager for the Mead-Morrison Division of the McKiernan-Terry Corp., retired June 30 after 43 years of service with McKiernan-Terry and its predecessor companies.

F. J. Balzer has been appointed sales representative for the Seattle, Wash., District sales office of Rockbestos Products Corp. Mr. Balzer was formerly with the Roebling Co.

A. F. Skipp, Jr. has joined the Herr Equipment Corp. as a sales engineer. Mr. Skipp comes to Herr after three years with the Westinghouse Electric Corp. Prior to that time he was affiliated with the Gulf Refining Co.

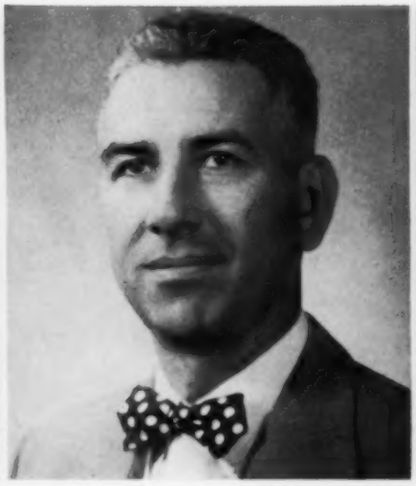
Henry H. Platek has been appointed advertising manager of the Cleveland Worm & Gear Co. and its affiliate, the Farval Corp. He joined the sales department in 1945 and served subsequently as assistant sales supervisor and assistant advertising manager.

B. B. Flick, formerly lubrication engineer for the Detroit Division of E. F. Houghton & Co., has been transferred to the Pittsburgh Steel Mill Division in charge of sales and service.

Frank E. Davis was appointed manager of Reliance Electric & Engineering Co.'s newly-established Mahoning Valley sales office in the Warren-Youngstown area of Ohio. In addition, **William K. Schlotterbeck** moves from district manager in Buffalo, N. Y., to head up the new Dallas, Texas, office, and **Walter L. Brehmer,** who

ROBERT L. STOCKUS

HOWARD E. KUEHN



H. R. LOXTERMAN

EDWARD W. POTTMEYER

DREVER

Continuous STRIP ANNEALING FURNACE LINE

Delivery end of furnace for low carbon tin plate strip installed in a large Canadian steel plant.

This furnace has an installed electrical input in heating and soaking zones of 3000 KW for a rated production of 37,000 lbs/hour on .0099″ x 33″ wide strip running at 550 FPM.

Furnace equipment is designed to handle strip in thicknesses from .0075″ to .020″ in widths varying from 19″ to 38″.

HNX atmosphere gas is used to purge the furnace.

DREVER COMPANY

..... RED LION ROAD and PHILMONT AVE., BETHAYRES, PA.

B&W Silicon Carbide Refractories for metal-working furnaces

To meet the specialized requirements of the primary metals industry, B&W manufactures Silicon Carbide Refractories in a variety of shapes and sizes. These durable refractories are produced in B&W's Augusta, Ga., works to the same rigid quality control standards used in making all B&W Refractories. See your local B&W Refractories Engineer for further information.

B&W Silicon Carbide Rolls

B&W Silicon Carbide Recuperator Tubes

B&W Silicon Carbide Special Shapes

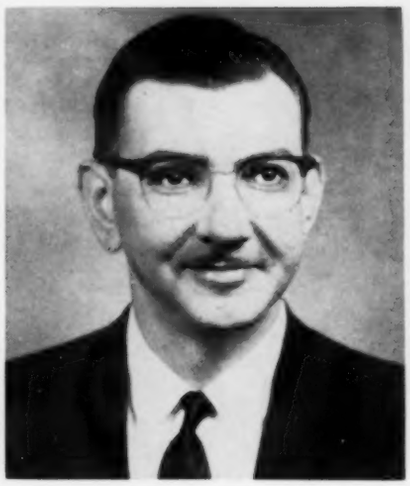
BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

B&W REFRACTORIES PRODUCTS: B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables, Plastics and Mortars • B&W Silicon Carbide

R558

R. B. HEPPENSTALL, JR.



KING D. CHRISTOPHER

EMORY W. BELL

RALPH H. SCHOLL

has been in charge of the sales office in Syracuse, N. Y., is appointed district manager of the newly created central western New York district. **Frank A. Denison,** district manager in Houston, Texas, heads up the Gulf Coast district. **Henry A. Cirbee** goes to Washington, D. C., to operate the new office there.

Robert B. Heppenstall, Jr., general manager of the Bridgeport, Conn., plant of Heppenstall Co., has been appointed general manager of the company's Ring Division, with headquarters at the Indianapolis, Ind., plant. **Charles B. Cobun,** associated with the company's Chicago district sales office, has been appointed manager of ring sales, and also will have his headquarters at the Indianapolis Plant. He succeeds **Charles A. Shenberger,** who resigned.

King D. Christopher has been named general manager of the newly-established Los Angeles Division of Clark Controller Co. A Clark 20-year veteran, Mr. Christopher has been district sales manager in Los Angeles since 1951. The new division will include engineering and manufacturing departments as well as handling Los Angeles area sales.

Emory W. Bell was named project engineer of the Rolling Mill Division of E. W. Bliss Co. Previously Mr. Bell was associated with Westinghouse Electric Corp. for 10 years.

Charles P. Whitehead has been elected president of the National Roll & Foundry Co. He is also president of the General Steel Castings Corp., of which National Roll is a subsidiary. **William A. Curran** and **J. Harvey Johnston** were re-elected vice presidents. At the same time the appointments of **Ralph H. Scholl** as manager-roll sales for National Roll, and **William Johnston, Jr.** as manager-castings sales, were announced. Mr. Scholl was with Pittsburgh Rolls for many years in the capacity of manager of sales. Immediately before joining National Roll, he was manager of roll sales for Birdsboro Steel Foundry & Machine Co. Mr. Johnston has been with National in a sales capacity for several years. He had previously been with Kensington Steel Co.

James M. Wilson, for 39 years a field engineer attached to the Pittsburgh, Pa., office of Metal & Thermit Corp., retired as of June 30, 1956. He will continue as a consultant to Metal & Thermit until the end of the year.

James L. Hamilton, Jr. has been appointed as western sales manager for the Mead-Morrison Division of the McKiernan-Terry Corp. Mr. Hamilton, who has been with the company as a sales engineer, replaces **S. F. Knight** who recently retired after 43 years with the company.

Call or Write STAMCO for...

Corrugating and Complete Line of Culvert Equipment—Slitting and Coiling Equipment for Ferrous and Non-Ferrous Material in All Capacities—Warehouse and Steel Mill Cut to Length Lines for Shearing and Levelling Sheets from Coils—Shears for Shearing Sheets and Plates Both Underdriven and Overdriven Types in all Capacities up to 1¼" plate.

STAMCO, Inc., New Bremen, Ohio

on-the-spot-cooling for ... CRANE CABS • PULPITS • HEAT RELIEF ROOMS

LINTERN

AIRE-RECTIFIERS

Larco, inc.

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Distributors of Lintern Corporation products

TIPS FROM A ROLL MAKER'S NOTEBOOK

MACKINTOSH-HEMPHILL DIVISION, E. W. BLISS COMPANY, Pittsburgh 3, Pennsylvania

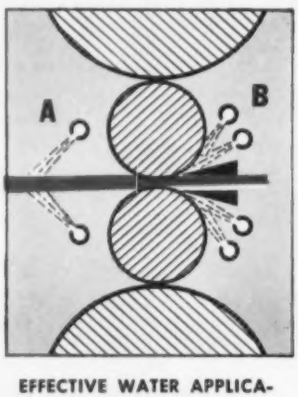
Cast mill rolls • Johnston cinder pots • rotary tube straighteners • end-thrust bearings • heavy-duty lathes • steel and special alloy castings

Choosing work rolls for hot strip finishing trains

In continuous hot strip mill operation, the highest frequency of time-consuming roll changes usually occurs in the early stands of the finishing train. Conditions here are severe: the reductions taken are heavy, and the strip is still thick enough to carry much of its original heat.

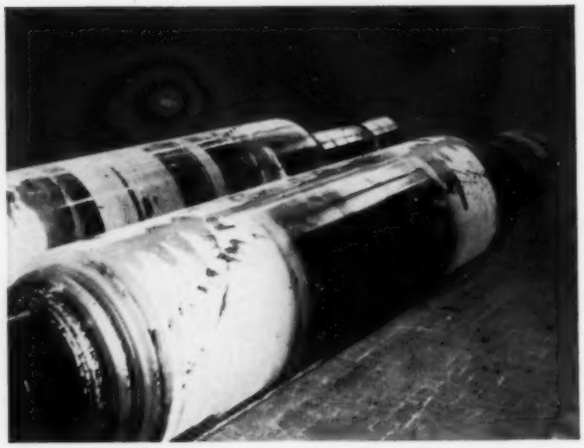
Water: the secret of longer roll life—Banding is a chief cause of premature roll failure in these stands. This peculiar tendency is related to the amount and size of graphite in a roll's surface, and to the adequacy of the cooling system. At high temperatures, graphite tends to pull out of the surface, leaving tiny fissures. Rolling pressure then forces in small particles of scale. These offer footholds for further scale build-ups, which are rapidly rolled into elongated bands.

Thus, cooling is vital. Water should be applied at a pressure of 140-to-200 psi, and in such a way that a large volume actually reaches the roll surface. The nozzle arrangement should be designed to create uniform cooling over the entire work surface. In some cases, additional sprays on the pass line are necessary.



EFFECTIVE WATER APPLICATION includes high-pressure sprays (A) aimed against the strip to push the scale out of the rolls and high-pressure water (B) in large quantities applied to the roll surfaces as close to the point of contact with the strip as the mill design permits.

Choice of rolls can make or break a rolling schedule—Where it is impractical to cool the rolls thoroughly, it is still quite possible to minimize roll changing by using Mack-Hemp *Midland Superalloy* rolls. These are nickel-chromium-molybdenum alloy steel rolls containing no graphite and capable of being heat treated to high hardness levels. As a result, they are extremely resistant to spalling and fire cracking, affording no foothold for scale.



ROLL BANDING on hot strip mill work rolls is a principal cause of uneven gage across the width of the strip. It brought about the early removal of this pair of rolls.

Where rolls can be adequately cooled, *Mack-Hemp Nironite "F"* double-poured high-nickel grain rolls actually will roll greater tonnages than alloy steel rolls. The indefinite chill of the first pour keeps the graphitic content of the iron low near the roll surface, while the second pour produces a strong, ductile core.

For less severe conditions, the *Mack-Hemp Nironite A or B* grades of grain roll give an excellent account of themselves. Although they show more graphite near the surface, they frequently turn in surprising tonnages between roll changes.

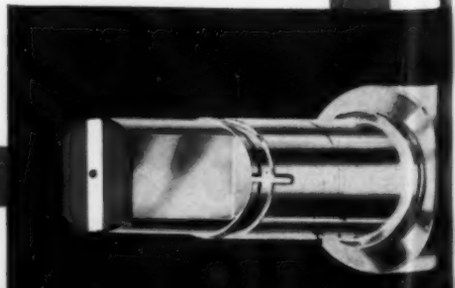
Mack-Hemp is as interested as you are in securing maximum output from your mills. If there are troublesome "roll-wreckers" among them, why not call upon us for help in selecting rolls to beat your special problems? There's no obligation. Write us today.

MACKINTOSH-HEMPHILL

You get more tonnage from the rolls with the Striped Red Wabblers

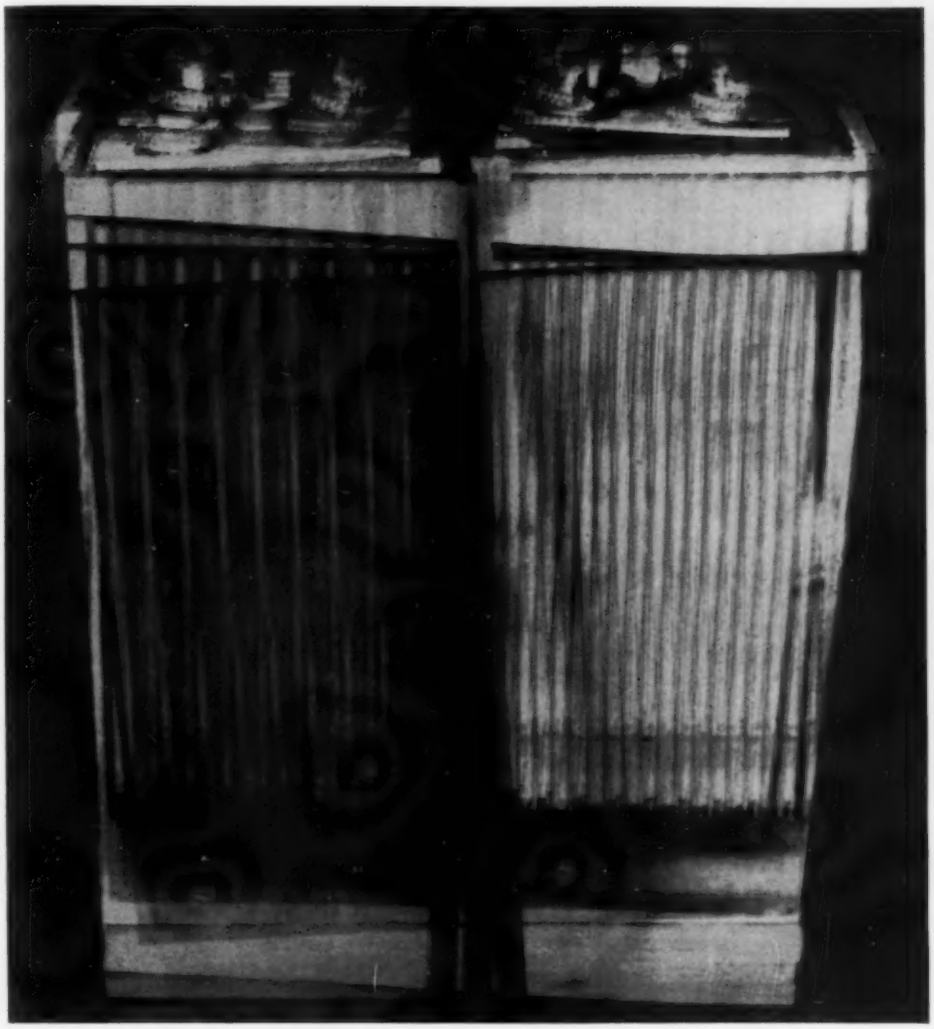
Division of E. W. BLISS COMPANY

Presses, Rolling Mills, Special Machinery

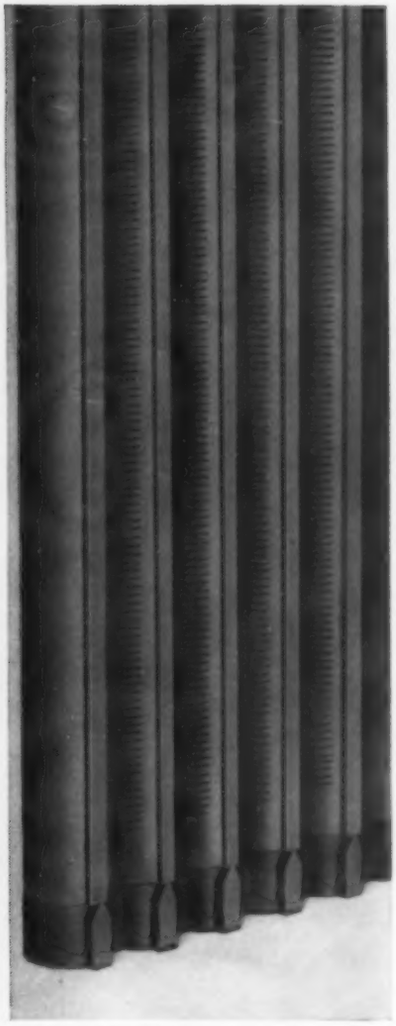


EXIDE-IRONCLAD BATTERIES

For electric industrial truck operation

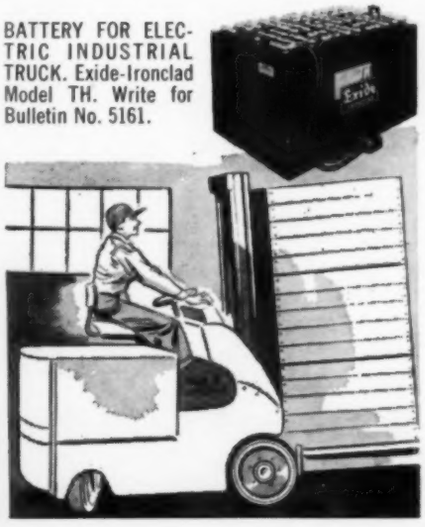


Actual photo taken during vibration torture test on an Ironclad Battery



Section of Ironclad positive plate

Vibration can't loosen active material — can't shorten battery life



BATTERY FOR ELECTRIC INDUSTRIAL TRUCK. Exide-Ironclad Model TH. Write for Bulletin No. 5161.

When a heavy duty storage battery gets the "shake treatment," battery life is literally at the mercy of the bond between the positive grid and the active material. Heavy shedding means short life.

But look what happens in an Exide-Ironclad Battery. Active material is held firmly captive inside the plastic power tubes. Hair-thin slits let electrolyte in, but keep active material from falling out. In prolonged vibration tests, this unique design has proved to be a valuable battery life stretcher. These findings are confirmed in the long, dependable service of Exide-Ironclad Batteries in typical high-vibration applications.

This superior performance is only one of the many extra advantages in Exide-Ironclad Batteries — advantages that have earned them an unmatched reputation for long life and high capacity. When you order heavy duty batteries, or the equipment that requires them, be sure to specify Exide-Ironclad. Write for detailed bulletin. Exide Industrial Division, The Electric Storage Battery Company, Philadelphia 2, Pa.

Exide®

MODERN BUSINESS

AND MODERN SCHOOLS

NEED EACH OTHER MORE THAN EVER!

This has been a great year! America is building and replacing and thus moving faster than ever before.

Only one thing. Will the labor market keep pace? That's where schools are important. If your company isn't helping community groups to get modern schools, it's not apt to get the skilled people it needs. Self interest, civic spirit, or both, you should make schools your business, too.

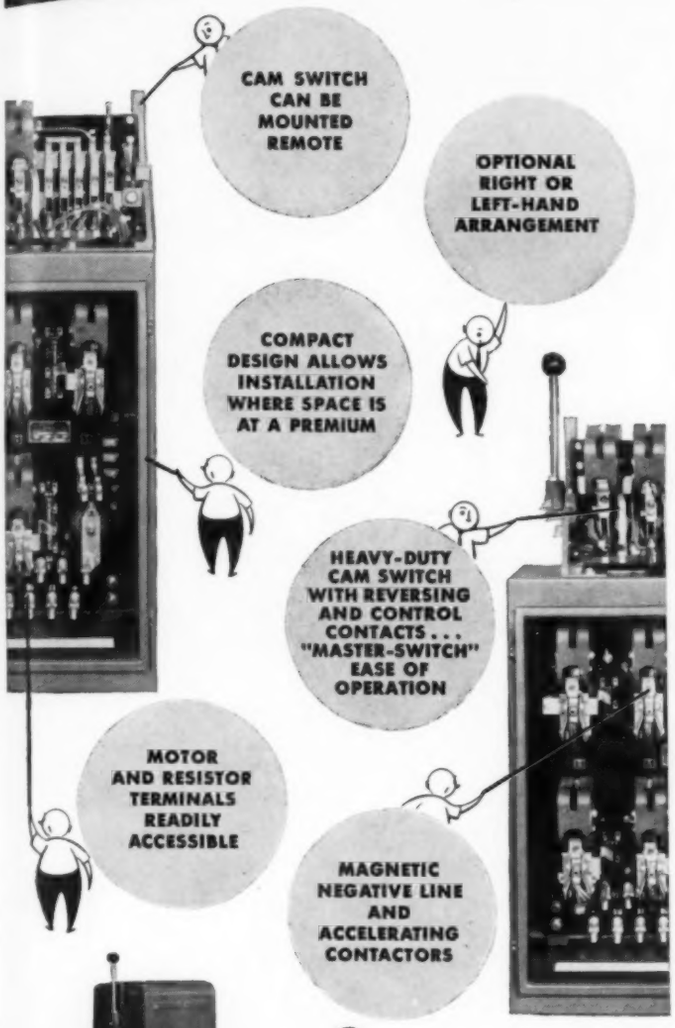
PUBLIC SERVICE ADVERTISING COUNCIL

Want to find out how to help in *your* community?
Get specific information by writing:
Better Schools, 9 East 40th Street, New York, N. Y.

NEW

HEAVY-DUTY D-C MAN-NETIC CONTROLLERS*

COMBINATION MANUAL and MAGNETIC CONTROLLER FOR CRANES—CHARGING MACHINES—D-C CONTROL JOBS


CAM SWITCH CAN BE MOUNTED REMOTE
OPTIONAL RIGHT OR LEFT-HAND ARRANGEMENT
COMPACT DESIGN ALLOWS INSTALLATION WHERE SPACE IS AT A PREMIUM
HEAVY-DUTY CAM SWITCH WITH REVERSING AND CONTROL CONTACTS . . . "MASTER-SWITCH" EASE OF OPERATION
MOTOR AND RESISTOR TERMINALS READILY ACCESSIBLE
MAGNETIC NEGATIVE LINE AND ACCELERATING CONTACTORS

2 TYPES AVAILABLE: REVERSE-PLUGGING OR DYNAMIC - LOWERING

Provide four speed points, reversing, with all advantages of full-magnetic control. Manually-operated cam contacts are free of destructive arcing . . . extremely fast magnetic contactor action interrupts power circuit before cam-operated contacts are opened. EUCLID'S EXCLUSIVE "TIMELOK" feature offers maximum dependable acceleration timing without extra relays . . . permits unusually compact arrangement of the magnetic panel.

For more information, contact our representative in your area, or write or call THE EUCLID ELECTRIC & MFG. CO., MADISON, OHIO.
Ask for Bulletin 4400-4401.

*PATENT APPLIED FOR.

THE EUCLID ELECTRIC & MFG. CO.
MADISON, OHIO

THE EUCLID ELECTRIC
EUCLID
AND MFG. CO., MADISON, OHIO

at last . . . the solution to

really tough gas-cleaning problems

Sub-micron fumes are the *really tough* problems in gas cleaning. These fumes cannot be economically or effectively controlled by conventional cleaning devices.

However, the CHEMICO P-A VENTURI SCRUBBER is proving its success in solving these *really tough* problems in more than 150 commercial installations and in more than 70 pilot investigations.

The table lists some of these commercial installations. All of these *really tough* problems and many more are being solved with complete satisfaction to users of P-A VENTURI SCRUBBERS.

PROCESS	DUST OR FUME	INSTALLED CAPACITY CFM
Incinerator—Flue Fed	Fly Ash	32,000
Incinerator—Sodium Disposal	Na_2O	9,000
Incinerator—Industrial	Radioactive Dust	6,000
Dry Ice & CO_2 Plants	Amine Recovery	72,400
CO_2 Gas for Process	Fly Ash	500
Boiler Flue Gas	Fly Ash & SO_2	4,300
Enamel Frit Furnace	Dust & HF	11,900
H_2SO_4 Concentrator	H_2SO_4	49,800
Copperas Roasting	H_2SO_4	34,250
Cobalt Ore Roasting	H_2SO_4	65,000
Chemico Wet Type Acid Plant	H_2SO_4	41,000
Chloro-Sulfonic Plant	H_2SO_4	600
Phosphoric Acid Plant	H_3PO_4	91,900
Phosphoric Acid Concentrator	H_3PO_4	194,000
Phosphor Copper Furnace	H_3PO_4	15,000
Smelting—Non-Ferrous		
Blast Furnace	Lead & Organic	12,000
Reverb. Furnace	Lead Compounds	23,500
Comb. Blast & Reverb.	Lead Compounds	7,000
Brass Furnace	Zinc Oxide	7,500
Ajax Furnace	Beryllium Fumes	4,000
Steel Plant		
Oxygen Steel Process	Iron Oxide	140,000
Blast Furnace	Coke & Iron Oxides	788,000
Zinc Sintering	Zinc Oxide	75,000
Wood Distillation	Tar Products	3,500
Na_2SiF_6 Dryer	SiF_4 & Dusts	700
Iron Chloride Concentrator	$FeCl_2$ & HCL Mist	40,000
Unknown	Carbon Black	1,700
Lime Kiln	Lime & Na_2O	18,000
Detergent Spray Dryer	Chemical Fume	250,000
Furfural Residue Burner	Fly Ash	36,000
Nodulizing Kiln	Manganese & Lead	25,000
Aluminum Pot Lines	Tar Fog, Fluorides	40,000
Carbide Furnace	Metal Oxides	1,000
Asphalt Plant	Rock Dust	80,000

Write to our P-A Sales Department for Bulletins

P-A VENTURI SCRUBBERS

(PEASE-ANTHONY)
CHEMICAL CONSTRUCTION CORPORATION

525 WEST 43RD STREET, NEW YORK 36, N. Y.
Telephone LOngacre 4-9400
Technical Representatives Throughout the World
Cable Address: CHEMICONST, N. Y. CC-309

FILE No. 97

the case of-- THE PULLER THAT PULLED THE PRINTER OUT OF A HOLE

With the big, multi-color offset printing press running at near capacity--it looked like a sure thing for the prominent Chicago container manufacturer* to complete the large, "Rush" carton order several days sooner than promised.

Then--the red ink began to run light! One of the ink distribution rollers had frozen solid. Instead of being able to make the necessary replacements in a few hours--three days were lost before the foreman phoned this company and said: "We're in a hole! Can you help us out, right away?" Armed with the know-how...plus...a hydraulic puller--this company's field engineer solved the stubborn dismantling problem in less than fifteen minutes.

Helping customers out of holes is not unusual for this company. In fact, giving customers the utmost in service--day after day--has been company policy for years. Thus, when you order bearings and bearing specialties from *this* company--you'll get immediate delivery. And, you can call for expert Bearing Engineering Service when you need it. In addition, you can ask for Bearing Surveys any time. And ALL for the price of the bearings! Why not dial the number below—NOW?

OTC

HYDRAULIC PULLER

One of the famous brands of bearings and specialties regularly carried in stock--for IMMEDIATE DELIVERY

* Name on request

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Turn your 'tired' machine tools into profitable performers

Simmons puts outstanding facilities and 46 years of experience into rebuilding and modernizing your used (and abused) machine tools. Your old equipment, of any size and any type, can be returned to the manufacturer's original specified tolerances through Simmons **Engineered Rebuilding.**

Savings are great. Unconditionally guaranteed **Engineered Rebuilding** is usually completed at half the cost of a new tool! Find out about the large savings available to you in initial cost, production, and maintenance through Simmons **Engineered Rebuilding.**

Simmons special-application machines . . .

Special equipment to perform particular machining operations at important savings in time, materials, and initial outlay have been successfully designed and built by Simmons for numerous major metalworking companies. Ask about the advantages which may be possible on **your** production line by the use of one or more special-application machines.

"The Simmons Way"

Write today for your copy of the current issue

How are your used machine tools given "a new lease on life" by Simmons **Engineered Rebuilding?** You will know after reading the picture-and-caption case histories in the latest issue of "The Simmons Way." Examples of modernization, and the designing of special-application machines, are shown. Send for your free copy now.

Check these machines now available from stock

No. 2 Medart Bar Straightener
16′ x 2″ Sellers Pyramid Rolls
Morton Hydraulic Draw Cut Shaper
No. 5 Cincinnati H.P. Plain Miller
50-ton Lucas Forcing Press
48″ x 41′ American G.H. Lathe
50″ Sellers Wheel Lathe
78″ Betts Vertical Boring Mill
10-16′ Betts Vertical Boring Mill
16′ Niles Vertical Boring Mill
12′ Niles Vertical Boring Mill
No. 4 LeBlond Boring Lathe
30″ x 48′ Niles Boring Lathe
16″ x 77′ Niles Boring Lathe
No. 420 Barnes Deep Hole Drill
No. 3 B&S Universal Grinder
16″ x 36″ Norton Plain Grinder
10″ x 96″ Norton Plain Grinder
1H-6 Libby Turret Lathe, Chucking
3-R Gisholt, Long Bed
4-R Gisholt, 9¼″ Hole

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SIMMONS ENGINEERED Rebuilding
GIVES MACHINE TOOLS A NEW LEASE ON LIFE

SINCE 1910 . . . *Builders and rebuilders of unconditionally guaranteed machine tools*

Simmons Machine Tool Corporation
1712 North Broadway, Albany 1, N.Y.
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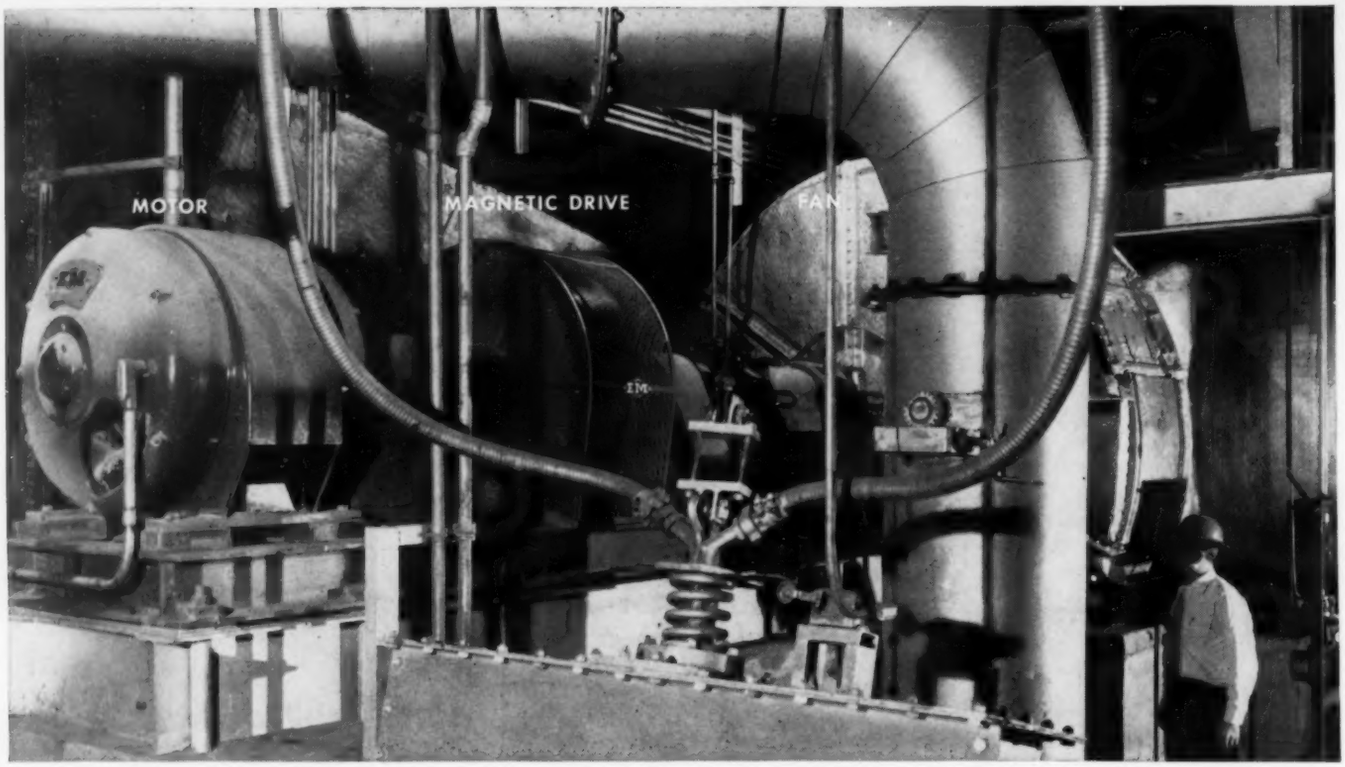


A waste-heat boiler induced draft fan in a large steel mill receives driving power and precise speed control from a 200 hp, 720 rpm E-M Synchronous Motor and a 200 hp, 350/705 rpm EM Adjustable-Speed Magnetic Drive.

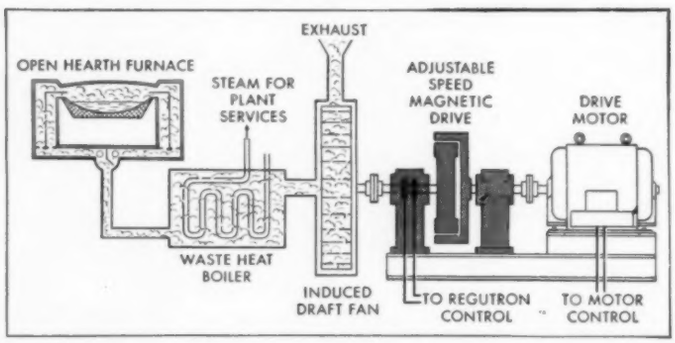
How to reduce erosion of waste-heat boiler induced draft fans

Many modern steel plants now use waste heat from banks of open hearth furnaces to produce steam for plant services. An induced draft fan draws waste gas through a waste-heat boiler to recover heat from open-hearth gases usually exhausted out a stack.

Speed control of this fan is essential for economical operation, and the E-M Adjustable-Speed Magnetic Drive is the best answer to this need. It transmits torque electromagnetically from the constant speed drive motor to the fan, responding automatically and precisely when speed changes are signalled. This Drive, with the sensitive E-M Regutron Control, provides *true* speed control regardless of variations in operating conditions.

Sizable reductions in fan blade erosion are achieved, as the fan is not required to run constantly at full speed against the highly abrasive gases when reduced output is wanted. The Magnetic Drive is equally effective and economical in drawing cool air through the boilers during shut-down for boiler maintenance or repair.

See how this Drive can save costs and increase over-all efficiency in your plant. Ask your nearest E-M sales engineer for details, and write for E-M Publication No. 1107 on Magnetic Drives.



Here, in a simplified diagram, is how the E-M Adjustable-Speed Magnetic Drive fits into the Waste-Heat Boiler system, providing precise, automatic control of the induced draft fan.

ELECTRIC MACHINERY MFG. COMPANY
MINNEAPOLIS 13, MINNESOTA

E-M

4400-TPA-2145

Magnetic Drives make draft fans do
EXACTLY WHAT YOU WANT THEM TO

Publication Service...

AUGUST, 1956

You Can Obtain . . .

. . . any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Note: Post cards expire three months after publication date.

(1) Foundry Data Book

The Whiting Corp., has published a pocket size booklet that provides practical data on foundry operations. This illustrated booklet gives information concerning cupolas, electric furnaces and transformers, fuels, ladles, melting points, temperatures, weights and other foundry operations. Entitled, "Useful Information for Foundrymen," the booklet includes reference tables as well as space for working notes and an index. (Bulletin FY-175)

(2) Plug Valves

Application data for plug valves are given in a 36-page catalog published by DeZurik Shower Co. The catalog illustrates their complete range of plug valves from 1/2 in. to 20 in. Also explained is the simplicity of design and the use of an eccentric-shaped plug and an eccentric raised seat in the valve body. (Catalog No. 54, Sec. 1)

(3) Nondestructive Testing

Magnaflux Corp., has available a booklet that describes how a magnetic force can detect defects. The bulletin entitled, "Seeing Isn't Always Believing" explains this nondestructive testing and illustrates the different units for detecting defects in magnetic materials, nonmagnetic metals and solids, nonconducting ceramics, brittle coatings for stress measurement of actual working parts.

(4) Descaling Machines

Equipment for continuous, mechanical descaling by shot blasting is described in a brochure published by the Pangborn Corp. Details of construction, actual installations and specifications, are illustrated. Equipment to descale sheet 60 in. wide at speeds of from 10 to 195 lfm using from two to eight abrasive throwing wheels is described, and savings in space and processing over pickling are documented. (Bulletin 608)

(5) Centrifugal Dust Collector

A new bulletin that explains the operation and construction of the multiple tube dust collector has been published by Research-Cottrell, Inc. With the aid of numerous drawings, cutaway views, and collection efficiency and capacity nomigraphs, the bulletin explains how the dust collector operates on centrifugal collection principles and incorporates new design features to boost collection efficiency and gas handling capacity. Tables give design data for the six available sizes of the dust collector, ranging from three to 20 tubes. (Bulletin 100)

(6) Fork Trucks

Construction details, operating characteristics and maintenance features of the new Clarklift line of fork trucks are described in a 16-page brochure now available from Clark Equipment Co., Industrial Truck Division. Numerous photographs and simplified drawings help explain many of the engineering features of the six-model line. A special section on Clark's new Hydratork Drive describes the operation and interchangeability features of the power train. The Clarklift's two separate braking systems are illustrated and described, as are a number of safety and comfort features. Accessibility characteristics are detailed, and a series of action photos shows how the Clarklift can be prepared for major servicing in a few minutes. Included is a list of 34 major components which are interchangeable on all models in the line.

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51	BAILEY METER CO.	SPEC. E12-5	Receiver recorder.
52	BLAW-KNOX CO FOUNDRY AND MILL MACHINERY DIVISION		Continuous, mechanical chipper.
53	BLISS CO., E. W.	CATALOG 40-A	Rolling mills.
54	BUFFALO FORGE CO.	BULLETIN FD-205	Radial blade fan.
55	BUSSMANN MFG. CO.	BULLETIN FIS	Fuses.
56	CHEMICAL CONSTRUCTION CORP.		Venturi scrubbers.
57	CLEVELAND WORM AND GEAR CO.	CATALOG 400	Speed reducers.
58	CUNNINGHAM CO., M. E.	DATA SHEET 613	Pneumatic billet marker.
59	CUTLER-HAMMER, INC.		Line welded, bolted and special magnets.
60	DE LAVAL STEAM TURBINE CO.	BULLETIN 0504	Centrifugal compressors.
61	ELECTRIC CONTROLLER AND MFG. CO., DIVISION SQUARE D CO.	BULLETIN 900	All-welded lifting magnets.
62	ELECTRIC CONTROLLER AND MFG. CO., DIVISION SQUARE D CO.	BULLETIN 1145-E	Contactors.
63	ELECTRIC MACHINERY MFG. CO.	E-M PUBLICATION NO. 1107	Adjustable-speed magnetic drive.
64	EUCLID ELECTRIC & MFG. CO., THE	BULLETIN 4400-4401	Controller for cranes.
65	EXIDE INDUSTRIAL DIVISION, ELECTRIC STORAGE BATTERY CO., THE		Batteries.
66	FARREL-BIRMINGHAM CO., INC.		Roll grinders.
67	FOXBORO CO.	BULLETIN 427	Electronic instruments.
68	FRANTZ CO., INC., S. G.	BULLETIN PM-44	Magnetic separators.
69	GENERAL ELECTRIC CO.	GEA-6127	Speed variators.
70	HOMESTEAD VALVE MANUFACTURING CO.		Steam cleaner.
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79	PANGBORN CORP.	BULLETIN 1210	Blast cleaning.
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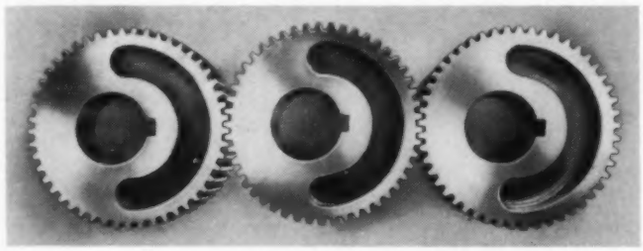
1011 EMPIRE BUILDING

PITTSBURGH 22, PA.

Applying Gearing Effectively in the Steel Industry

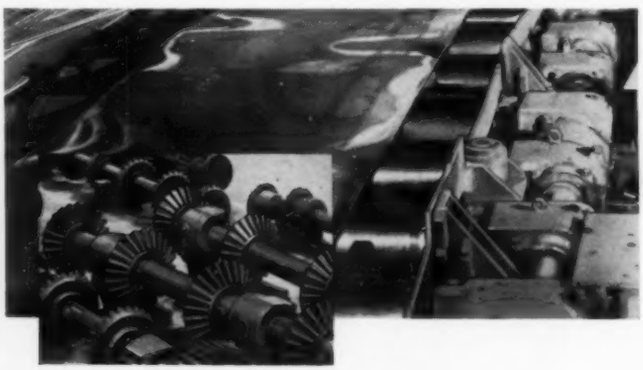
by **Robert Ritzel**
Regional Marketing Manager, Denver
Western Gear Corporation

The requirements for gears and gear drives in the steel industry are both diverse and specialized. Only a company that possesses an intimate knowledge of the industry can provide the most effective answer to these requirements.



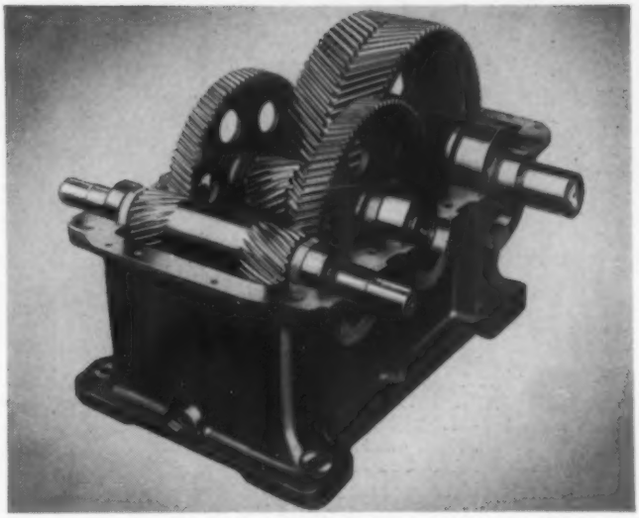
PRECISION ELLIPTICAL GEARS

Western Gear technicians after considerable research have developed a new concept of generating elliptical gears. By generating, the blank and cutter revolve together continuously with the cutter fed across the gear blank as it revolves. Previously elliptical gears were produced by a form cutter with its inherent inaccuracies. Our method insures a proper gear tooth profile, minimizes tooth to tooth spacing tolerances and produces each tooth normal to the true elliptical pitch line. This precision method has resulted in greater life and smoother operation.



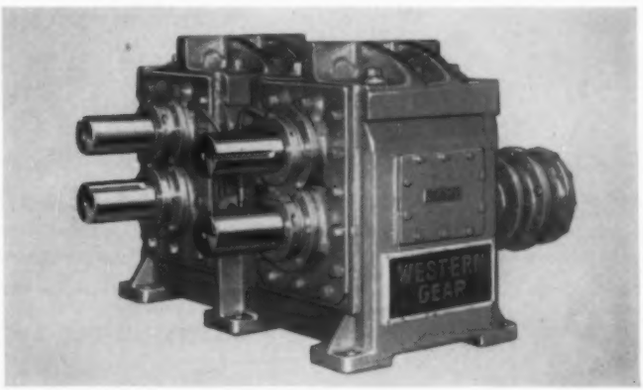
MITER GEARS

Based upon careful and continuous study of the industry Western Gear has gained recognition for many improved applications of gears. The photo shows gearing made for mill table rolls. Today miter gears for mill table rolls are made of carburized alloy steel and also through hardened and later flame hardened .40 to .45 carbon alloy steel. Western Gear maintains its own heat treating department to insure internal control of all heat treating processes.



SPEED REDUCERS

Over the years the steel industry has depended upon Western Gear to supply its speed reducer needs. Western Gear speed reducers are found on main mill drives and auxiliary drives in mills throughout the country. Some of the main applications are on slitter drives, shears, ingot buggy drives; also on cranes, for the hoist, trolleys and bridge drives as well as all types of conveyors. Capacities range from 1 to 10,000 HP. Western Gear speed reducers are of balanced design. Roller-type antifriction bearings carrying only radial loads and all thrust loads are cancelled out due to opposed helix angles, thus giving unrivalled, troublefree service.



PINION STANDS

Mill pinion stands or combination speed reducer and mill pinion stands built by Western Gear meet the rigid steel industry requirement for custom designed and manufactured equipment. Western Gear has supplied units to steel mills around the world ranging in capacity from 5 to 5,000 HP. Conservative design with compact, rigidly constructed gear cases, precision cut gearing and carefully selected bearings are all a must in the manufacture of a Western Gear mill pinion stand.

Western Gear over the years, with the close cooperation of the steel industry, has accumulated know-how about the many problems that face the steel mill engineer. We invite your inquiries on any power transmission or gear applications that you have and you can be assured that your inquiry will be given the personal attention of one of our key steel mill specialists. Please send your inquiries to Western Gear Corporation, P.O. Box 182, Lynwood, California.

MILLING NIPPLE THREADS

AS PARTNERS IN
YOUR PROGRESS . . .

OUR FINE MACHINING – is a *plus* factor!

Finishing operations on GLC electrodes, anodes and mold stock are performed with the utmost precision. A strict system of gaging and inspection is required at this stage.

The craftsmanlike spirit of our milling, machining and inspection personnel is a distinctive *plus factor* in the efficiency of GLC carbon and graphite products.

The high degree of integration between discoveries in our research laboratories, refinements in processing raw materials, and improved manufacturing techniques is further assurance of excellent product performance.

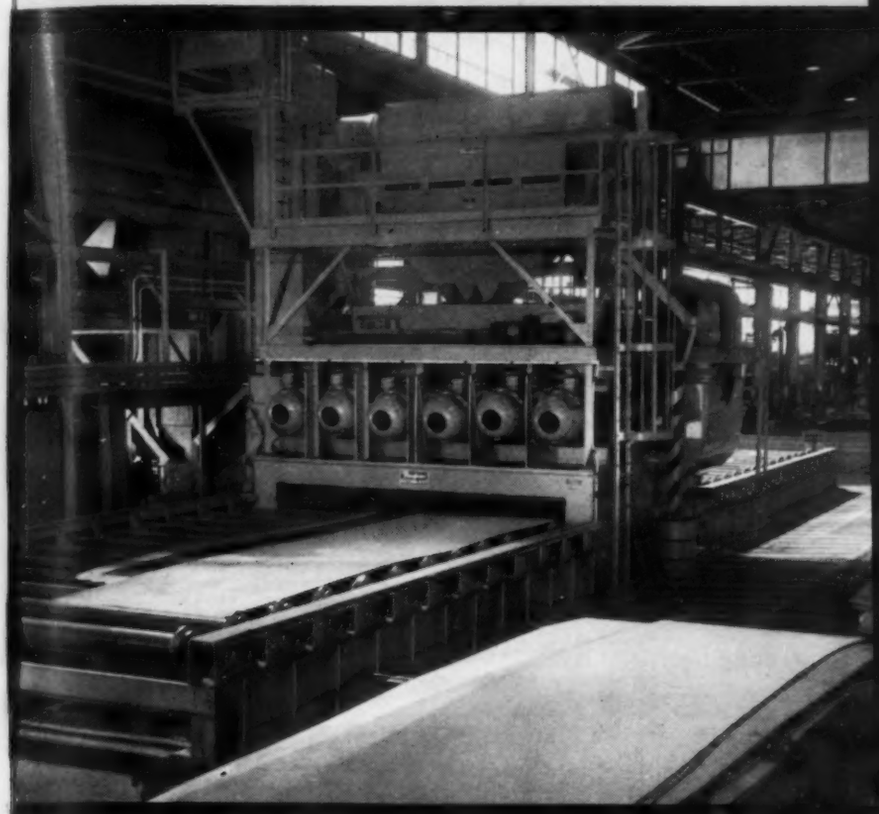
ELECTRODE
GLC®
DIVISION

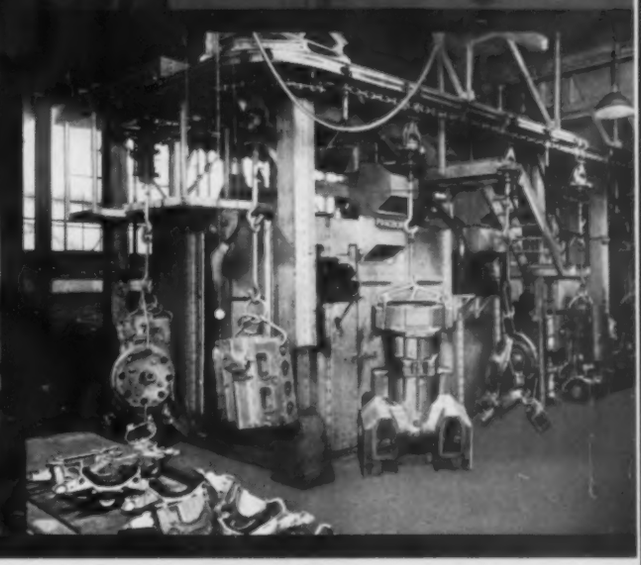
Great Lakes Carbon Corporation

GRAPHITE ELECTRODES, ANODES, MOLDS and SPECIALTIES

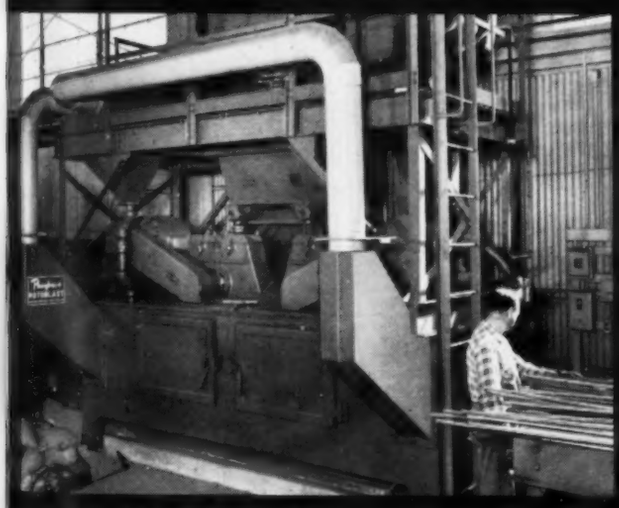
ADMINISTRATIVE OFFICE: 18 East 48th Street, New York 17, N.Y. PLANTS: Niagara Falls, N.Y., Morganton, N. C. OTHER OFFICES: Niagara Falls, N.Y., Oak Park, Ill., Pittsburgh, Pa. SALES AGENTS: J. B. Hayes Company, Birmingham, Ala., George O. O'Hara, Wilmington, Cal. SALES AGENTS IN OTHER COUNTRIES: Great Northern Carbon & Chemical Co., Ltd., Montreal, Canada; Great Eastern Carbon & Chemical Co., Inc., Chiyoda-Ku, Tokyo, Japan

If you have





an unusual blast cleaning problem,



If you are a company with a special cleaning problem, Pangborn offers you a special service—a machine designed for your individual needs. It might be a descaling machine for bars, sheets and coils, a continuous-flow barrel or a monorail cabinet like the machines shown here . . . or it might be completely different. You may need to clean cylinder blocks, bathtubs or any unusual ferrous or nonferrous castings, forgings, stampings. If so, Pangborn engineers will study your problem and its relation to your production line. Then they'll design a Pangborn machine that gives you better cleaning and faster production at lower cost. Pangborn has proved it in hundreds of cases. Pangborn can prove it to you! Write today for Bulletin 1210 to: PANGBORN CORP., 4400 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment.*

*U. S. Pat. #2184926 (other patents pending)

Pangborn Rotoblast® can solve it!

Pangborn

BLAST CLEANS CHEAPER

Rotoblast Blastmaster® & Continuous-Flo Barrel

Rotoblast Tables & Table-Rooms

Special Blast Rooms & Cabinets

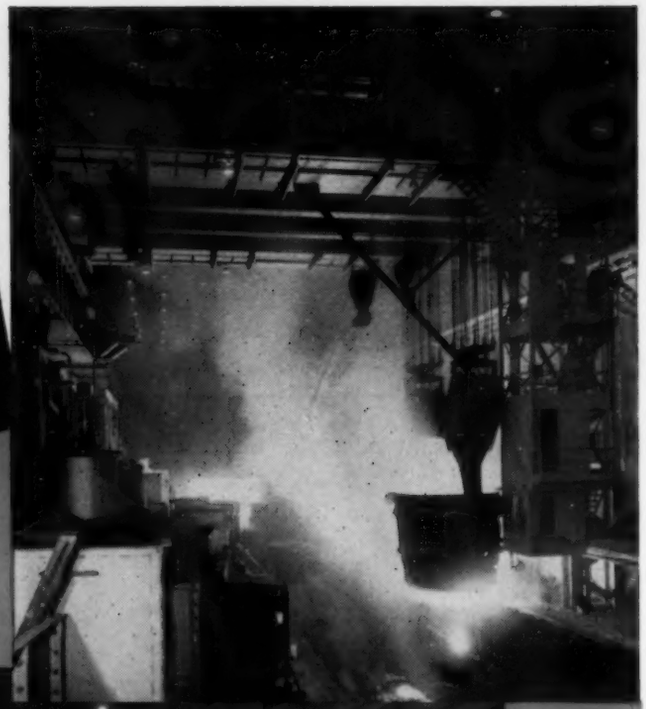
Pangborn Dust Control Equipment

Distributors for Malleabrasive and Tru-Steel Abrasives.

OVER 20,000 BEARINGS ARE LUBRICATED AT FAIRLESS WORKS BY

Trabon

LUBRICATION SYSTEMS



PHOTOS COURTESY U. S. STEEL CORPORATION

The following wide range of equipment at U. S. Steel's new Fairless Works is lubricated around the clock by TRABON *positive* centralized lubricating systems: Wellman Ore Bridge; E. W. Bliss Hi Scale Breakers; Arthur G. McKee Blast Furnaces; Atlas Ore Transfer Cars; Wean Combination Line; Alliance Cranes; Cleveland Cranes; American Bridge Cranes; Wellman Charging Machines; Dravo Ore Unloaders; E. W. Bliss 80″ Pickle Line; Mesta 45″ Slabbing Mill; Mesta 80″ Hot Strip Mill; Morgan 10″ Merchant Mill; Continental 40″ Blooming Mill; United Billet Mills; Morgan Scale Yard Crane; E. W. Bliss Cold Mills.

This installation of TRABON systems, automatic and manual, assures each bearing point accurate lubrication as frequently as it is required.

Write for our detailed literature for further information on TRABON versatile, trouble-free lubricating systems.

Trabon ENGINEERING CORPORATION

1814 E. 40th STREET • CLEVELAND 3, OHIO

Oil and Grease Systems

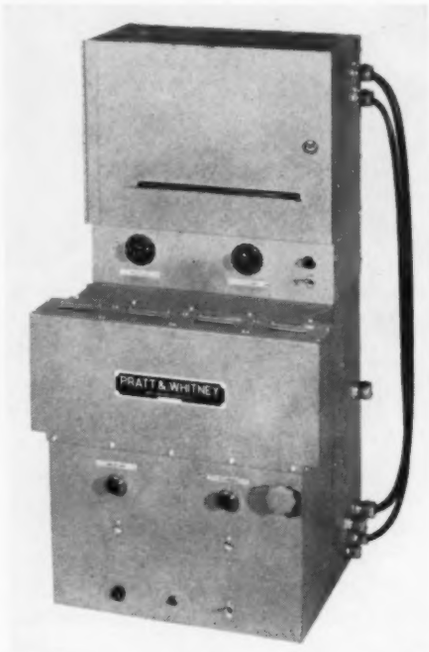
Equipment News...

PRODUCTION ANALYZER

▲ A production analyzing totalizer that prints a card record of the on-gage and off-gage footage of rolled strip metal has been developed by Pratt & Whitney Co., Inc.

Operating in combination with either contacting or non-contacting continuous strip thickness gages, the unit prints a permanent record in numerical, rather than chart, form.

A typical installation on a finishing mill will include the undersize, on-gage, oversize, and total footages in a coil on the last pass through the



strip mill. At the end of the pass the operator inserts the standard production work card in the printer, and these footages together with the time, the date, the coil number, the operator's number, and sets of tolerance zones, are imprinted for the permanent record. During this operation the counters are automatically reset for the next coil.

AIR CONTROLLER

▲Announced by the Bristol Co. is a new series 500 air controller. This unit features high stability of control action without loss of sensitivity, coupled with a wide proportional band.

The controller is offered for measuring and controlling such variables as pressure, vacuum, temperature, liquid level, flow, differential pressure, and mechanical motion. Control modes available include narrow band (on-off), proportional, reset, derivative, and reset plus derivative. Cascade, selective, and ratio control models are also available, as well as program control models.

Among the design features of the new controller are wide proportional band width (½ to 400 per cent) with easy shift in width, full zero derivative setting on triple mode controller, reset action stops for prolonged deviation from set point under severe load changes, easy reversal of action, and a precision linkage arrangement allowing complete disassembly and recalibration with only one adjustment.

CONTROL SWITCH

▲ A line of newly designed control switches called the Type M-2 are being manufactured by Delta-Star Electric Division, H. K. Porter Co., Inc. These multi-stage switches are rated 20 amperes continuous rating with 250 amperes short-time (3-second) rating.

Only 3⅞ in. high by 3¼ in. wide, the compact design permits easy wiring and quick inspection. Large terminal clearances and complete baffling between sections assures high interrupting capacity—at 250 volts a-c on inductive circuits, single break contacts are rated 25 amperes, double break contacts, 75 amperes.

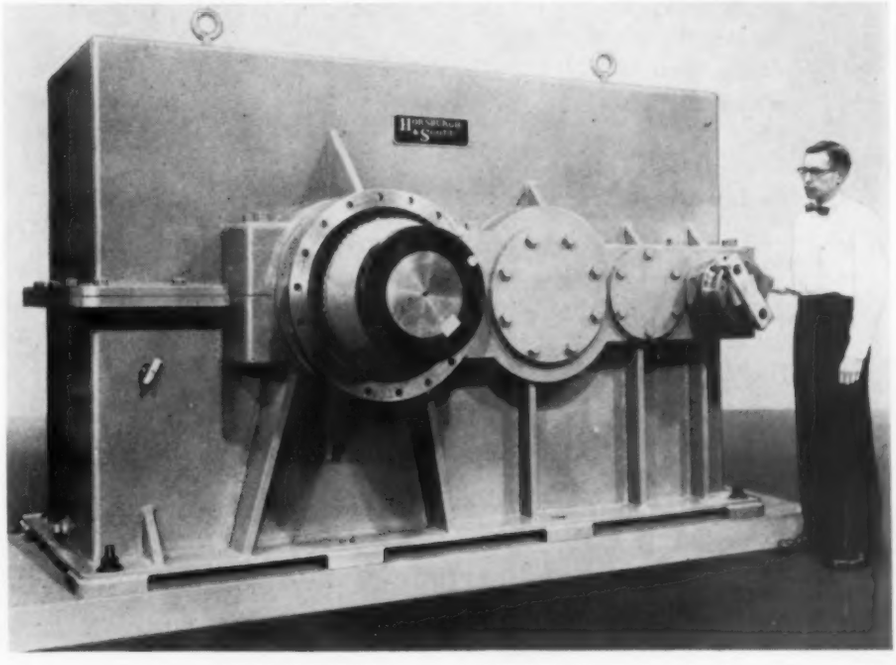
BUS WAY SYSTEM

▲ Announced by Electric Service Works, H. K. Porter Co., Inc., is the new, "Lec-Trol-Feed" enclosed trolley bus way system for supplying power up to 300 amperes at voltages up to 575 a-c or 250 d-c. Electric current can be supplied to cranes, hoists, welding equipment and other moving units.

The system's three insulated aluminum bus bars are arranged in a delta pattern and are completely enclosed in an aluminized steel

TRIPLE REDUCTION SPEED REDUCER

This Horsburgh & Scott Co. triple reduction speed reducer is used to drive the head shaft of a chain conveyor carrying tubing through a slow cooling furnace at a Midwestern steel mill. The unit, LT-7200L, contains Helical gears mounted on anti-friction type roller bearings housed in a solid construction of welded steel, 6½ ft high, 10 ft long, weighing 28,000 lb. Efficient performance for intermittent class eight service is provided with a ratio of 305-1 and a low speed shaft rating of 1,650,000 in.-lb torque.

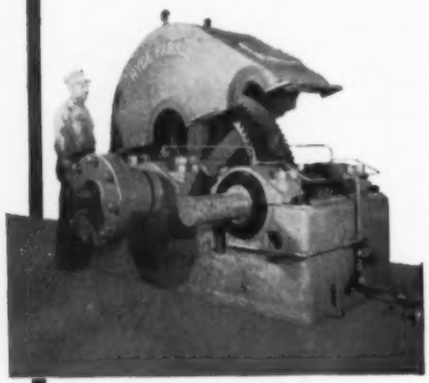


Hyde Park

RED CIRCLE Rolls ALLOY-CHILLED

Gray Iron Castings

Hyde Park Castings up to 80,000 pounds are sound, accurate and physically dependable.
Precision machining is done by skilled craftsmen in our modern machine shop.
Send your blue prints for quotation.



Mill Drive

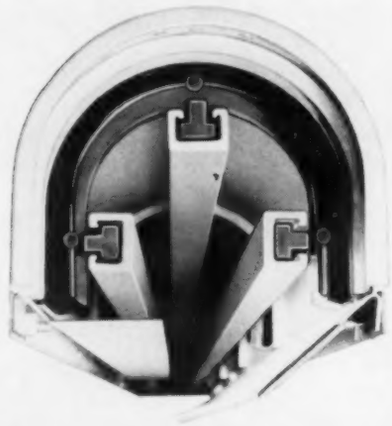
Machine Castings
Lathe Beds
Housings
Pinion Housings
Mill Housings
Shoe Plates
Layout Plates
Surface Plates

For finer finish, long life and greater tonnage, specify Red Circle Rolls.

Hyde Park
FOUNDRY & MACHINE CO.
Hyde Park, Westmoreland County, Pa.
ROLLS
ROLLING MILL MACHINERY
GREY IRON CASTINGS

housing. Maximum electrical leakage distance is provided by the delta conductor arrangement and petticoat-ribbed insulators. The bottom safety covers prevent accidental contact from below with current carrying members.

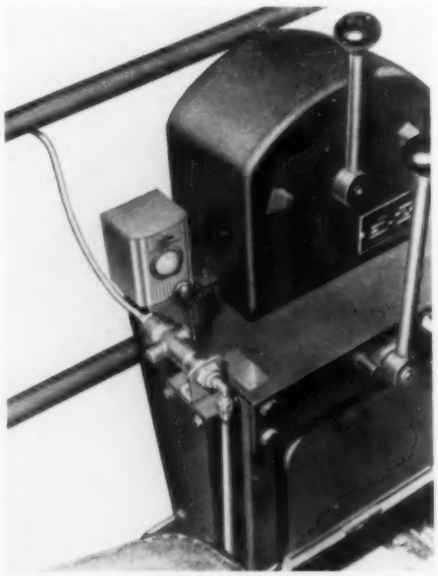
The system may be used either indoors or outdoors under most operating conditions, and is designed specifically to provide maximum economy, safety and life for straight runway applications.



Track sections are 30 ft long, thus reducing joints and installation time. A complete line of accessories is available. The trolley is available in 100, 200 and 300 ampere capacity.

BRAKING SYSTEM

▲ A new addition to Wagner Electric Corp.'s line of hydraulic brake systems features a spring-set, hydraulically released parking brake which is manually controlled by the operator and is entirely independent of electric power.



The new system, known as type HM-3, is designed to provide service and parking brakes on cranes and other rail guided equipment where an uninterrupted power supply is not available. It is also suitable for use on engine driven equipment.

The system retains all the advantages of a powerful and accurately controlled hydraulic service brake and a positive spring set parking brake of proved dependability. Its advantage for certain applications lies in the fact that automatic parking in the event of power failure has been eliminated.

The parking brake is released by one application of the control cylinder foot pedal and remains released until manually set by tripping a hydraulic check valve, permitting the service brake to be used as required. A green signal light remains on as long as the parking brake is released. The illustration shows these two units installed in a crane cab.

STRIP MILL DRIVE

▲ Weirton Steel Co.'s five-stand tandem cold strip mill with automatic thickness-gage control is now in operation at the Weirton, W. Va., plant. It is powered and controlled by General Electric Co. electric apparatus delivering 28,000 hp.

Part of Weirton's long range modernization and expansion program, the new mill is designed to deliver steel strip at a rate of over 7000 fpm. This is a rate equal to about 80,000 medium size tin cans per minute.

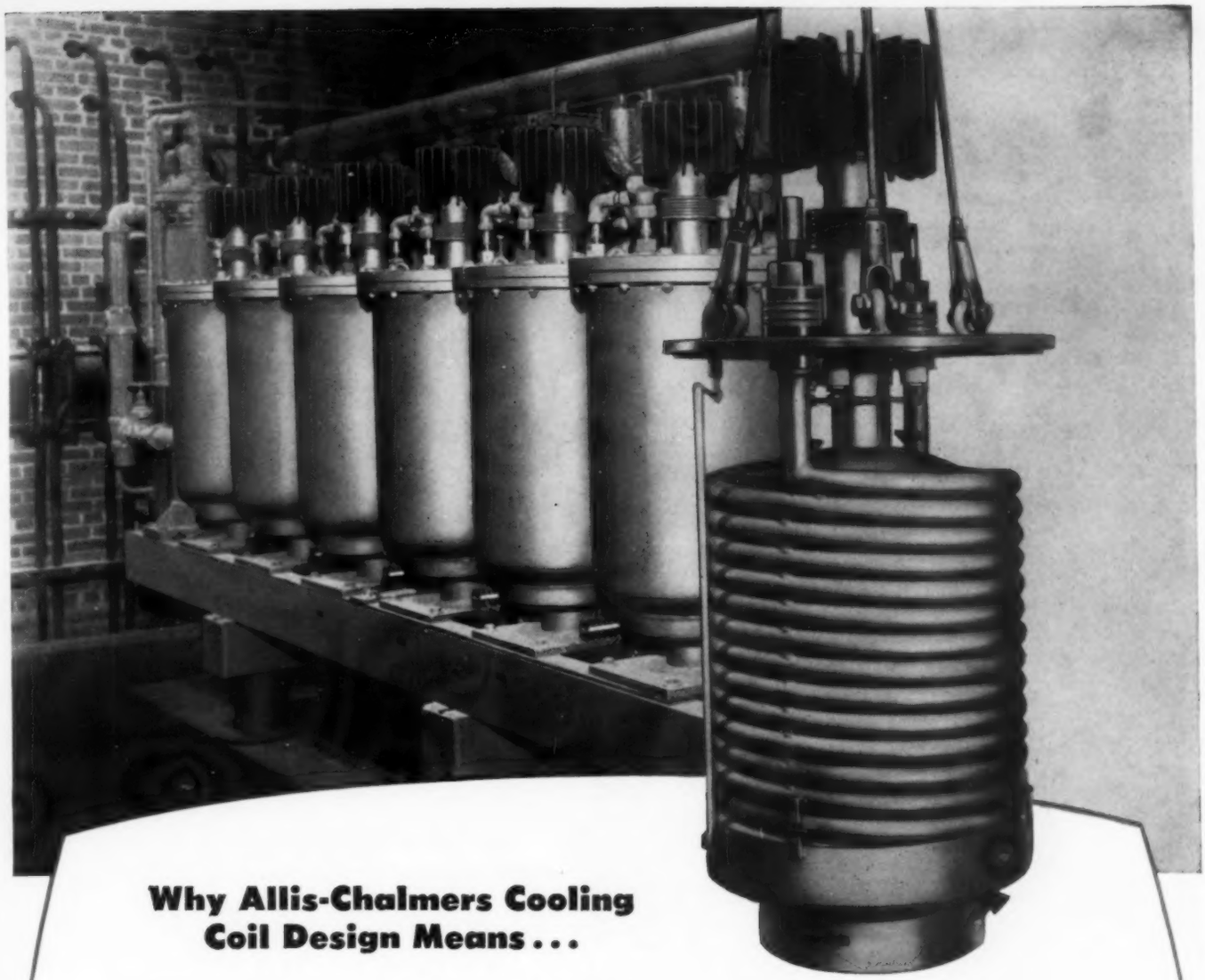
The mill will roll strip up to 48 in. wide and deliver at thickness down to seven thousands of an in.

The mill control includes newly developed high-speed-of-response amplidyne power amplifiers, and amplistat preamplifiers in a regulating system specially designed to precisely harness the 28,000 hp for fast, accurately coordinated acceleration and deceleration.

DUST COLLECTOR

▲ Problems due to atmospheric dust in the cooling air for a motor room at Columbia-Geneva Steel Division, U. S. Steel Corp., Geneva, Utah, are eliminated by efficient pre-cleaning. All the cooling air is filtered by Wheelabrator Ultra-filtration before being introduced to the room under pressure.

Wheelabrator Ultra-filtration is a development of Wheelabrator Corp.



Why Allis-Chalmers Cooling Coil Design Means . . .

Better Rectifier Operation

More Efficient Heat Transfer results from internal cooling coil. The steel coil surrounds active parts, offering more cooling surface and better heat transfer than other types. Unit maintains more uniform temperature and mercury vapor pressure.

Simplified Maintenance results from Allis-Chalmers unique unit construction. All active components are attached to the anode plate for easy withdrawal, dismantling, and re-assembling — as illustrated above.

Positive Arc Barrier is formed by the cooling coil, which is insulated from the tank. The main arc is confined within the coil, preventing arc transfer to the tank.

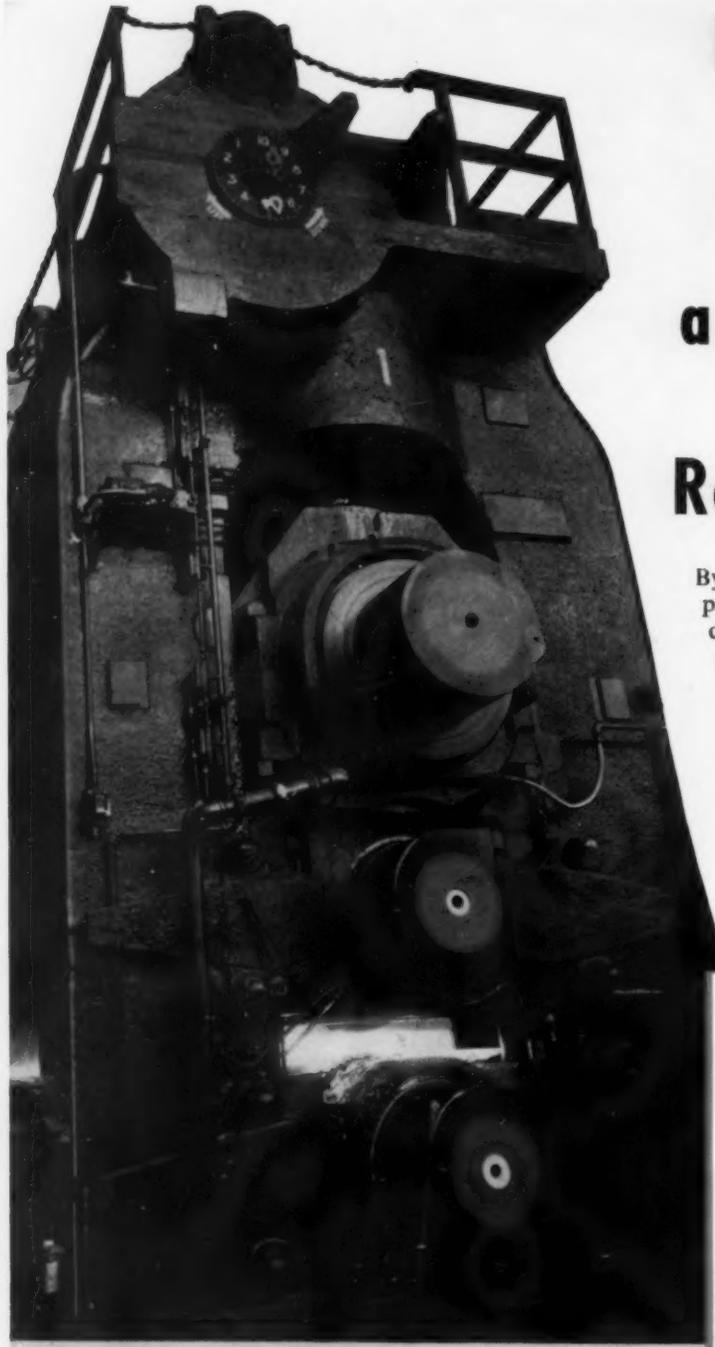
Years of Operation in hundreds of installations have proved the reliability, ease of operation, and simplified maintenance of Allis-Chalmers mercury arc rectifiers. You can get complete information at your nearby A-C office, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

LIVE BETTER ELECTRICALLY

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5084



HOW LEADOLENE* Klingfast and Spray Lubrication can increase Roll Neck Bearing Life

By using Leadolene Klingfast in a spray lubrication system pioneered by Brooks, roll neck wear can be substantially reduced. The system is designed to spray bearings and roll necks with a fluid lubricant through pneumatic atomizing nozzles which fan the lubricant over journal surfaces with adequate supply to the thrust collar. Grease grooves are eliminated to increase bearing load area, and bearing life is substantially extended. Remachining costs are reduced, lubricant consumption is cut down . . . *and considerable savings are gained through significant reductions in mill down time.* Write for Engineering Bulletin K-26.

**The I. P. Lubricant with Indestructible pH-ilm.*

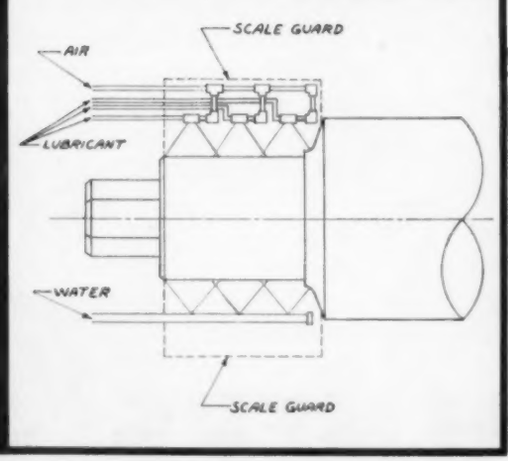
80 YEARS OF LUBRICATION SERVICE TO INDUSTRY

Read this Case Study

FOR PROOF OF LEADOLENE KLINGFAST'S SUPERIOR QUALITY AND COST REDUCING PERFORMANCE

In a lubrication study conducted over a period of one year on a 40″ blooming mill, Brooks Leadolene Klingfast proved its efficient, cost reducing qualities. Best competitive E. P. Lubricants were consumed at the rate of twenty drums per week, and bearings wore out in three weeks' time. With Leadolene Klingfast, bearings showed no wear after sixteen weeks and only three drums were consumed per week.

Roll Neck Journal and Bearing Spray



The Brooks Oil Company

Since 1876

Executive Offices and Plant, Cleveland, Ohio
Executive Sales Offices, Pittsburgh, Pa.
Canadian Offices and Plant, Hamilton, Ontario
Cuban Office, Santiago de Cuba
Warehouses in Principal Industrial Cities

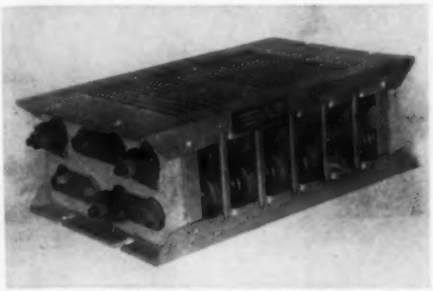
GUYAN
RESISTORS

Engineered and designed to eliminate resistor maintenance on troublesome mill applications.

Non-breakable helical coil construction ends burnouts due to warping and buckling of grids.

Sturdy, rugged steel construction eliminates shock and vibration troubles.

Custom designed for your conditions including excessive graphite accumulations.



With a quarter century of resistor engineering, we invite you to take advantage of our experience.

For complete information on Guyan Resistors, please contact the nearby Guyan Representative or our main plant at Logan, W. Va.

Baltimore, Md.—Durling Electric Co., 2505 St. Paul St.

Birmingham, Ala.—Ebbert & Kirkman Co., 2313 6th Ave. So.

Buffalo, N.Y.—Buffalo Electric Co. West Mohawk St.

Chicago, Ill.—John K. Byrne, 1515 W. Howard St.

Cleveland, Ohio—Mechanical Equipment Co. 3100 Prospect Ave.

Detroit, Mich.—Plant Equipment Co., General Motors Bldg.

Philadelphia, Pa.—George I. Wright 811 Commercial Trust Bldg.

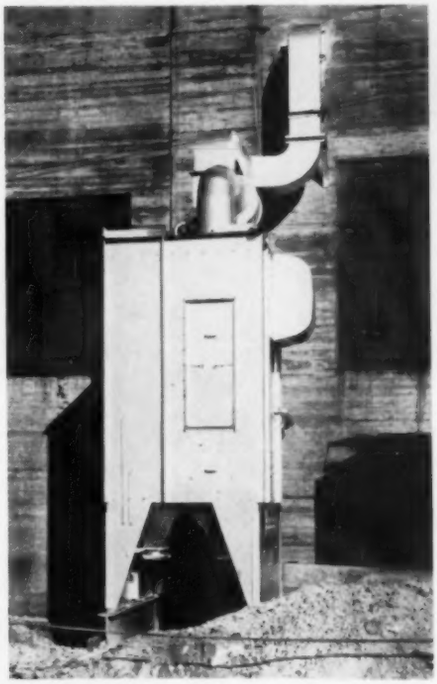
Pittsburgh 27, Pa.—P. R. Holden. 4860 Elmwood Dr.

●

GUYAN MACHINERY COMPANY

LOGAN, W. VA.

Process consists of filtering atmospheric air through cloth tubes coated with a filter aid. This makes it possible to trap even the finest particles of smoke, dust, and tarry matter that



might be present and thereby prevent their settling out on motor windings.

Collection efficiency of the particulate matter is better than 99 per cent. Not only is motor maintenance reduced, but filter system maintenance is also low. Collector requires attention only at intervals of one to three years.

ANODE CIRCUIT BREAKER

▲ A new anode circuit breaker (Type DM) for application with mercury arc rectifiers is available from the Westinghouse Electric Corp.

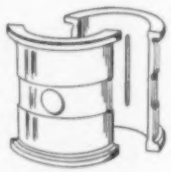
The high speed anode breaker trips only on high reverse current, and recloses automatically after a 15 second delay. This time can be shortened to as little as one second where necessary.

The new breaker is rated either 750 or 1000 volts d-c output, 2500 amperes rms continuous, and has an interrupting capacity of 75,000 amperes on the first loop of arc-back current.

Normally used in a six-phase arrangement, each pole has its own magnetic solenoid closing mechanism. Absence of mechanical connection between poles results in simple construction with fewer parts, ease of adjustment, less maintenance, and greater flexibility in arrangement.

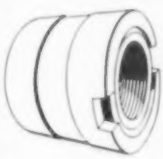
FLOOD CITY
for the best
BRONZE PARTS

FLOOD CITY Bronze Parts are best . . . best fitting . . . best wearing . . . all expertly machined from the best grade of hard, wear-resistant bronze or to your particular specification bronze.



For years Flood City has furnished quality bronze parts at a savings in metal weight and machining costs to a variety of industries

We welcome your inquiries concerning quotations and delivery on your bronze parts needs. Our reply will be prompt — and there is no obligation.



Be sure it's the BEST - specify FLOOD CITY

SERVICE FC FIRST

FLOOD CITY
BRASS & ELECTRIC CO.
JOHNSTOWN, PA.
PHONE: Johnstown 8-1281

FOR DEPENDABILITY, GRANITE CITY STEEL SPECIFIES OKOLITE-OKOPRENE CABLES

View of the new blooming mill at the Granite City Steel Co. plant in Granite City, Ill., from finished slab end. The entire mill, from the 5,000 hp motors for the two rolls to the control circuits, is wired with Okolite-Okoprene.

Simplicity of termination is one important reason for the trend to rubber-insulated high voltage cables. These are 12 kv rated Okolite insulated cables at the rear of the 6.9 kv motor switchgear.

Sverdrup and Parcel, Consulting Engineers
J. Livingston and Company, Electrical Contractors

Continuous operation was a prime factor in drawing up specifications for the expansion of the Granite City Steel Company plant in Granite City, Ill. Every piece of equipment, including the electrical wires and cables, was selected on the basis of 24-hour-a-day operation.

High voltage distribution and low voltage control circuits are all wired with Okolite-Okoprene, the mold-cured, rubber-insulated cable that has established a reputation for dependability and long service life in industrial plants as well as utilities. Okolite insulation, which is applied by the Okonite strip-insulating process, is a thoroughly proved high voltage, natural rubber, oil base compound that resists heat, moisture and ozone. The Okoprene sheath, securely bonded to the insulation, provides a non-flammable weatherproof covering unharmed by long exposure to sunlight, acids, alkalies, fumes, heat and most oils.

For additional information on Okolite-Okoprene cables, write for bulletin IS-9000, The Okonite Company, Passaic, New Jersey.

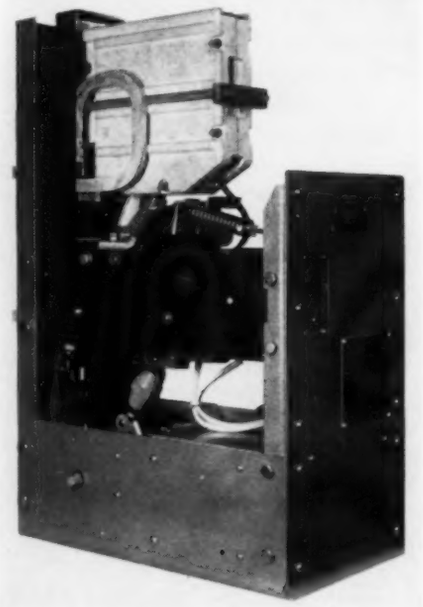
OKONITE insulated cables

2111

The individual pole units are pedestal mounted and are available either as a metal-closed draw out unit or as a stationary frame unit.

D-C CIRCUIT BREAKER

▲ Development of a new current limiting high speed d-c circuit breaker operable at 1000 volts and 1200 amperes continuous has been announced by I-T-E Circuit Breaker Co. Primary applications will be for protection of generators, and traction or



driving motors; also for feeder breakers and, in multiple pole assemblies, for anode protection.

Designed for extremely fast tripping and interruption of fault currents, the unit will interrupt in a total of .012 seconds, and limit current magnitude in .004 seconds. Breaker can be set for high speed tripping on either forward or reverse current.

It is built in single and multiple pole assemblies, each with its own individual closing motor, and can be wired for individual pole reclosing or automatic reclosing.

WELDING TORCH

▲ Air Reduction Sales Co. has announced a new welding torch, which features a "quick shut-off" valve, for production line, light gage welding and brazing jobs. Known as the Airco Style 600 Shut-Off Torch, it is a well balanced unit that weighs only 14 oz and is 7¼ in. long. A complete line of tips, mixers and extensions are available for use with this torch.

The valve permits instantaneous closing of the gas passages so that the operator can move from one weld-joint to another without the loss of oxygen and acetylene, and without carrying a "live" flame from one area to another. The quick acting lever is conveniently located between the gas valve knobs on the handle.

Other outstanding features of the new Airco 600 Torch are: front end is of high strength brass forging; torch head is made of durable monel metal; the Airco "corn-cob" non-slip handle; all mixers and tip mixer assemblies incorporate gas sealing rings; easy-grip oxygen and acetylene valve knobs; thumb operated, quick-acting shut-off lever; chrome plated welding tips for resistance to weld splatter; and stainless steel extensions.

RUST PREVENTIVE BASE

▲ A new multi-purpose rust preventive base which can be mixed with water, solvent or oil, or used neat, has been announced by E. F. Houghton & Co.

Identified as Rust Veto M.P., this water displacing rust preventive base has an exceptionally wide range of uses for indoor protection. When mixed with water, it provides a safe, non-flammable emulsion with high

for intense concentration of heat...

The BLOOM HTR BURNER

The Bloom HTR Burner provides identical operation on either gas or oil.

This burner enables the engineer to design a heat pattern with excellent results, because it has the unique characteristic of providing localized high heat release with low forward velocity. The burner can be located to fire directly at the material without flame impingement. Roof firing is easily accomplished and provides uniform hearth temperature.

This burner has been very successful in its application to tube upset furnaces; continuous strip annealing, coating, and pre-heating lines; high speed billet heating furnaces; and batch-type forge furnaces.

The Bloom High Thermal Release Burner with its sturdy construction is ideal for applications requiring speed and precision heating.

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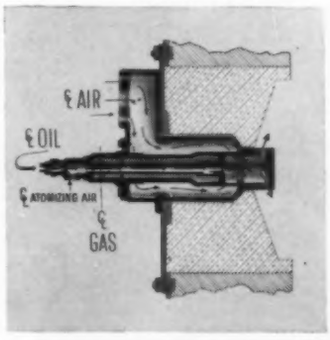

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stability and excellent protection value. Rust Veto M.P. can be used to replace dangerous solvents or similar flammable slushes and is especially economical when mixed with water.

Book Reviews . . .

"ASTM Standards on Metallic Electrical Conductors," 300 pages, 6 x 9 in., heavy paper cover, price, $3.50, includes all of the ASTM Standards pertaining to metallic electrical conductors which were developed by ASTM Committee B-1 on Wires for Electrical Conductors, and related standards from other committees of the ASTM. The December, 1955, edition of ASTM Standards on Metallic Electrical Conductors includes in their latest form 52 ASTM standards —43 specifications, 7 test methods, 1 recommended practice and 1 classification of coppers.

Standards cover: (1) copper, copper alloy and copper covered steel: wire; stranded conductors; rods, bars and shapes; pipes and tubes; (2) aluminum: wire; stranded conductors; rods and bars; (3) galvanized steel core wire; and galvanized iron and steel guy, messenger, span, overhead ground, and line wire.

Of the material included in this compilation, 20 of the specifications have been revised and one of the standards is new since the previous edition.

Copies of this 300-page book can be obtained from American Society for Testing Materials Headquarters, 1916 Race Street, Philadelphia 3, Pa.

"ASTM Standards on Copper and Copper Alloys," 654 pages, 6 x 9 in., heavy paper cover, price $5.75, contains all of the ASTM Standards pertaining to copper and copper alloys. The December, 1955, edition of ASTM Standards on Copper and Copper Alloys includes in their latest form 127 ASTM standards—110 specifications, 12 test methods, 2 recommended practices, 2 classifications (of coppers and copper-base alloys), and 1 definition of terms.

Copies of this book can be obtained from ASTM Headquarters, 1916 Race Street, Philadelphia 3, Pa.

"Evaluation of Insulating Oils — European Developments," (ASTM Special Technical Publication No. 172). 78 pages, 6 x 9 in., heavy paper cover, price $1.75, describes European developments in the testing of transformer oils in three papers and reports of research on the subject in France, Sweden, and England. This symposium is the sixth in a series of symposiums on insulating oils, and was presented in the fall of 1954 during a meeting of Committee D-9 held in Cleveland, Ohio.

Copies can be obtained from ASTM Headquarters, 1916 Race Street, Philadelphia 3, Pa.

"Significance of ASTM Tests for Petroleum Products," (Special Technical Publication No. 7-B), 134 pages, 6 x 9 in., heavy paper cover, price $2.50.

Each chapter discusses a particular property or characteristic, covering the importance of sampling, selection of test apparatus, the methods of test which apply and their significance. Full details of the individual test procedures are not published in this volume, but are found in the annu-

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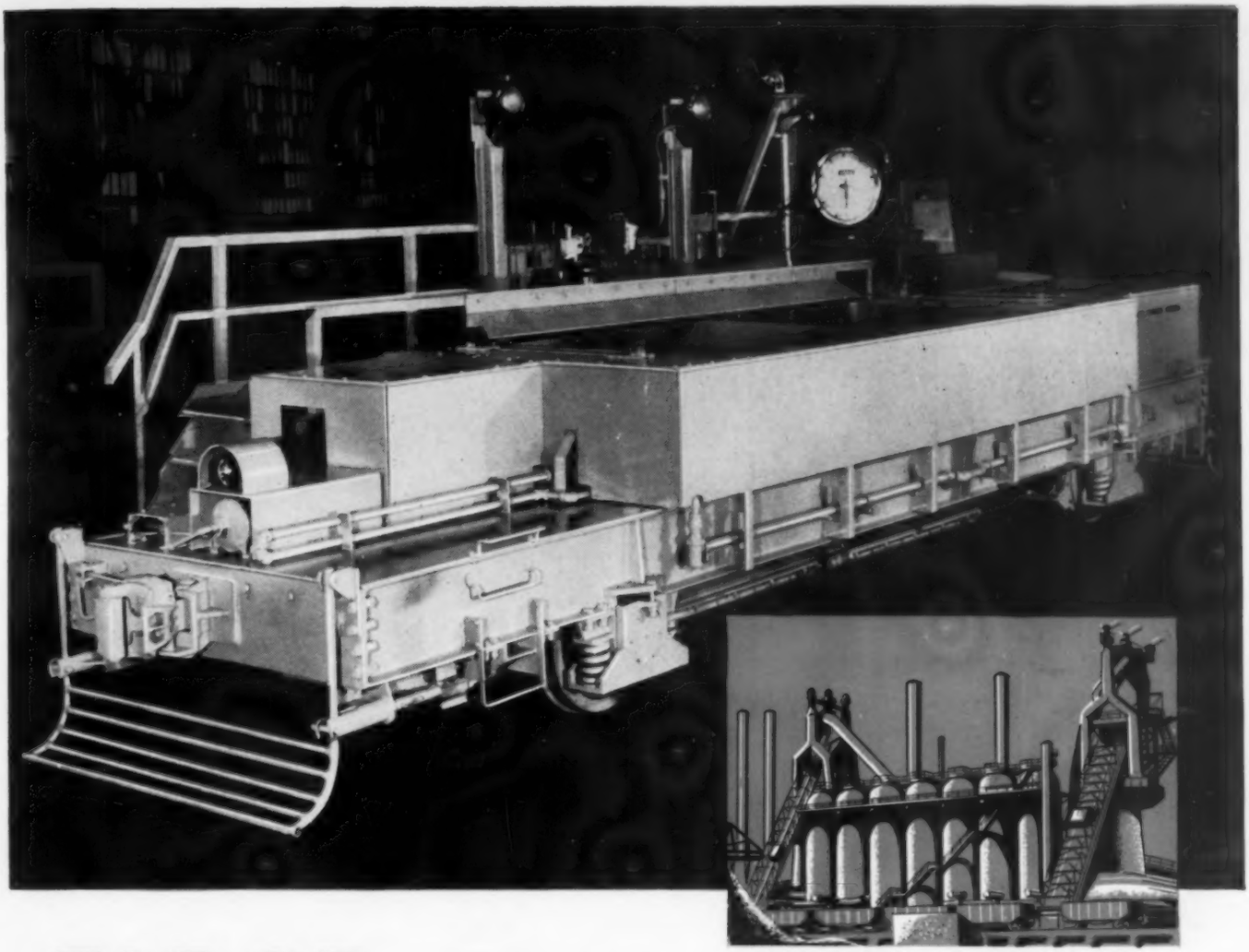

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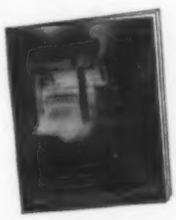

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ally published compilation "ASTM Standards on Petroleum Products and Lubricants."

Copies of this publication can be obtained from ASTM Headquarters, 1916 Race Street, Philadelphia 3, Pa.

"ASTM Standards on Electrical Insulating Materials" (D-9) (with related information), 656 pages, 6 x 9 in., heavy paper cover, price $6.00 (to members $4.50) is the latest edition of the compilation of standards on electrical insulating materials sponsored by Committee D-9 on Electrical Insulating Materials. It includes specifications and test methods issued by the society covering various types of materials in this field. The changes since the previous edition issued in 1955 comprise 12 revisions and 2 new items covering methods of testing silicone insulating varnishes and a recommended practice for cleaning plastic specimens for insulation resistance testing. The compilation includes 83 methods of test and specifications.

Two appendices, give proposed recommendations for writing statements on the usefulness of tests of electrical insulating materials, and proposed methods of test for dielectric constant and dissipation factor of aviation fuels. Data on the officers and personnel of the committee are also included.

These standards may be obtained from ASTM Headquarters, 1916 Race Street, Philadelphia 3, Pa.

"Symposium on Metallic Materials for Service at Temperatures Above 1600 F" (ASTM Special Technical Publication No. 174), 200 pages, heavy paper cover, 6 x 9 in., price $3.00, is available. The demand of engineers to attain greater efficiency in heat engines has created a need for metals to withstand the increase in operation temperatures. Steam power plant design engineers are pushing temperatures and operating pressures beyond the safe operating limits of the ferritic steels now in use, and the gas turbine engineers (and those concerned with devices such as guided missiles) are prepared to design for operation at temperatures higher than the 1600 F limit to which they have been confined for want of materials capable of satisfactorily withstanding higher temperatures of operation. This symposium, sponsored by the General Research Panel of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals, attempts to provide a basis of evaluation of a number of metallic materials, including cermets, which have been undergoing study in laboratories both here and abroad, to determine their suitability for higher temperature service. The papers discuss as many as possible of the properties—physical, chemical and mechanical—as well as methods of combating surface deterioration that are affected by temperature.

Copies of this publication can be obtained from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

"Panel Discussion on Pyrometric Practices" (ASTM Special Technical Publication No. 178), 78 pages, heavy paper cover, 6 x 9 in., price $1.50, defines the precision and control which can be recommended or specified in high-temperature test work. The Panel Session, organized by the Test Methods Panel of the ASTM-ASME

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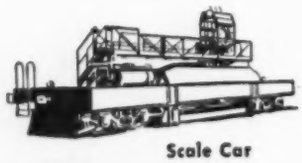
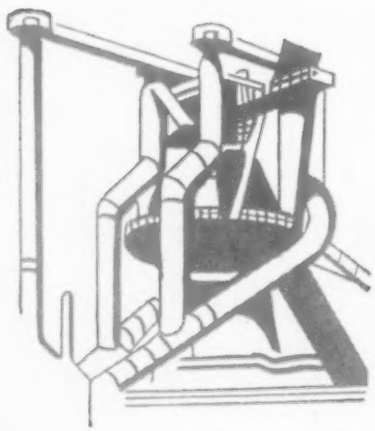
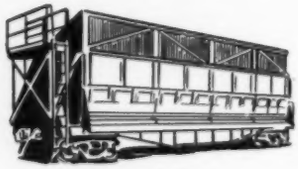


Scale Car



100-ton Ore Transfer Double Compartment, Bottom Dump



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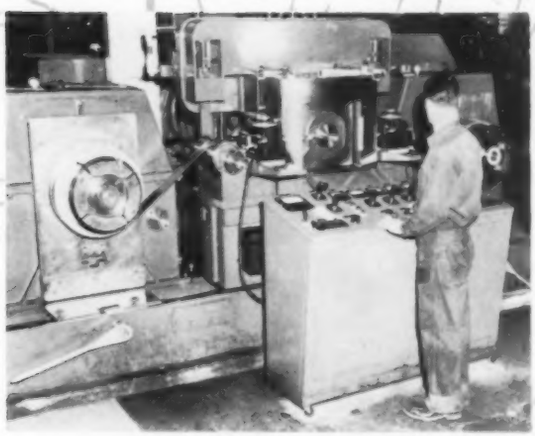

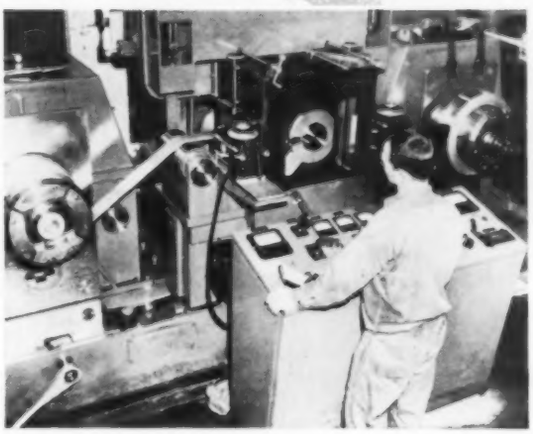

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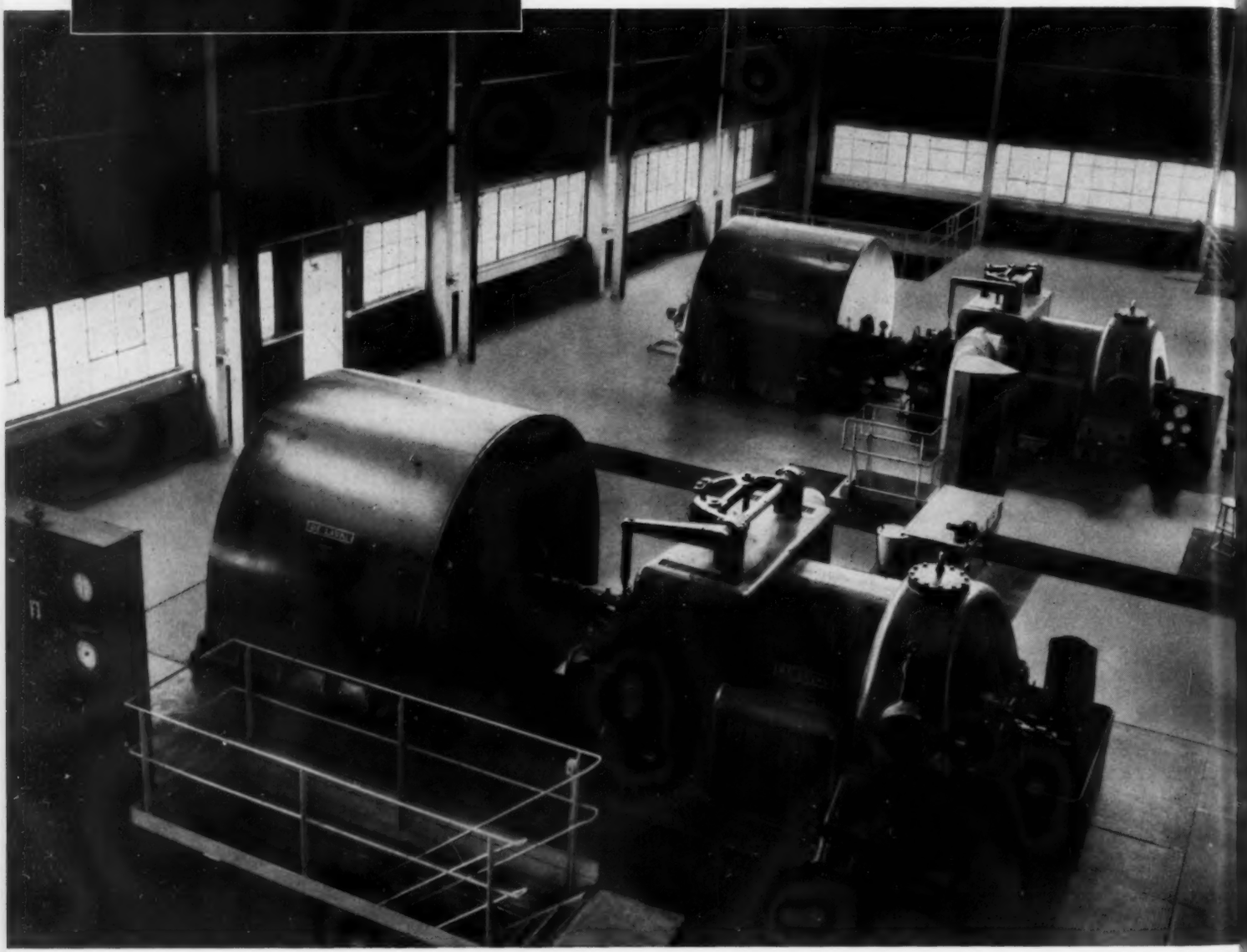

These two De Laval turbine-driven centrifugal blowers do a round-the-clock job in the McLouth Steel plant, Trenton, Michigan. Each has a rated capacity of 110,000 cfm of air; discharge pressure is 30 psig. Each is driven by a 12,400 hp, 2950 rpm De Laval steam turbine operating under steam conditions of 600 psig, 825 F with 2″ hg.

De Laval compressors are designed individually for each application to assure maximum efficiency and range of operation. Construction is rugged throughout. Casings and perfectly balanced rotors are built to take punishment. All parts are precision-made to limit gages. Materials are selected which will best meet the particular conditions of corrosion, pressure and temperature.

De Laval centrifugal blowers are built in single and multi-stage types to supply air in volumes up to 150,000 cfm for all classes of service in steel, gas and coke plants. The wealth of application experience acquired by De Laval over the years assures a correct and economical solution to your blower problem.

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DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY

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DL 980

Joint Committee on Effect of Temperature on the Properties of Metals, discusses work in this field, and is concerned with the ASTM recommended practices on high-temperature testing of metals, E 21, E 22, and E 85. The session was held at the ASTM Annual Meeting, June, 1955.

Copies of this publication can be obtained from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

"Recommended Equipment and Procedure for the Palletized Loading and Shipment of Refractory Products," Revised, May, 1956, has recently been issued by The Refractories Institute, First National Bank Building, Pittsburgh 22, Pa. The manual contains 46 pages, 8½ x 11 in., is assembled in a heavy paper cover and is available from the Institute office at $1.50. The scope of this revised manual has been enlarged to include the standard wooden pallet; pallet-load protection; carloading patterns; palletizing of insulating firebrick and bulk materials in bags, drums, and cartons; standard wooden end gates; method of carloading empty pallets for return shipment; and quantities of brick per pallet. The subjects are amply described by sketches as well as by text material.

"American Standard Requirements for Brushes for Electrical Machines" (C64.1-1956, revision of C64.1-1950), (Carbon, Carbon-graphite, Electrographitic, Graphite and Metal-graphite Brushes) sponsored by the National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y., has been recently approved by the American Standards Association, 70 East 45th Street, New York 17, N. Y. The standard contains 36 pages, 8½ x 11 in., is paper bound, and is available from either Association at $2.00. This standard has resulted from the work of the ASA Sectional Committee on Brushes for Electrical Machines, C 64 and represents general practice in design and manufacture, and provides practical information to assist the user in proper selection of such brushes. This edition incorporates many minor changes over the previous issue, as well as an expansion of the procedure for describing brushes. The scope of the standard includes definitions, dimensions and tolerances, and test procedures for brushes used in the electrical manufacturing industry.

"The Microphysical World" by William Wilson has recently been published by the Philosophical Library, Inc., 15 East 40th Street, New York, N. Y. The book deals with the very small things in the physical world, especially atoms, their structure and behavior. The acquirement of this knowledge is explained at length, and such topics as spectra and spectroscopy, x-rays, black body radiation, the Geiger counter and cyclotron are included, much of the text is the phenomena of heat, light, electro-magnetism, radio-activity, etc., traceable to molecules, atoms, and still smaller things. The book is addressed to the intelligent layman; simple language is employed, and is not burdened with mathematics, although it conveys some idea of the relevant modern theory which plays such a dominant part in the understanding of microphysical phenome-

(Please turn to page 236)

Test Installations Prove:

DeZurik Plug Valves

SHUT TIGHT ON BLAST FURNACE GAS TO SOAKING PITS!

A large steel mill recently tested an 18" DeZurik Valve on blast furnace gas to soaking pits. As a result of that test, 135 DeZurik Valves were ordered to go into service on blast furnace gas lines — further evidence of the decided advantages DeZurik Valves bring to so many difficult installations. With DeZurik Plug Valves, dead-tight shut-off is assured — despite scale or dirt in the line — without lubrication!

DeZurik Plug Valves are available in sizes from ½" thru 20"; with manual, gear, pneumatic, hydraulic or electric operators; and in a full range of materials. Write for complete details; representatives in principal cities.

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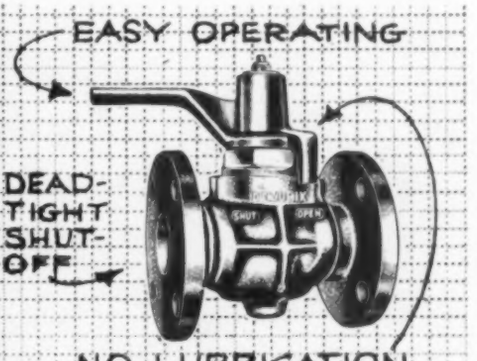

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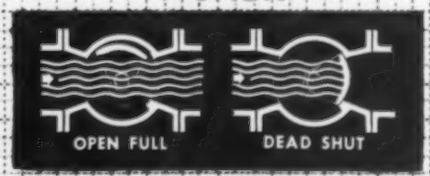

The plug of a DeZurik Valve is eccentric in cross-section, matching the eccentrically-raised body seat. The resilient-faced plug closes around dirt and scale on the valve seat assuring positive shut-off. In opening a DeZurik Valve, the plug backs away from the seat and swings wide open in a quarter-turn — without friction, without lubrication!

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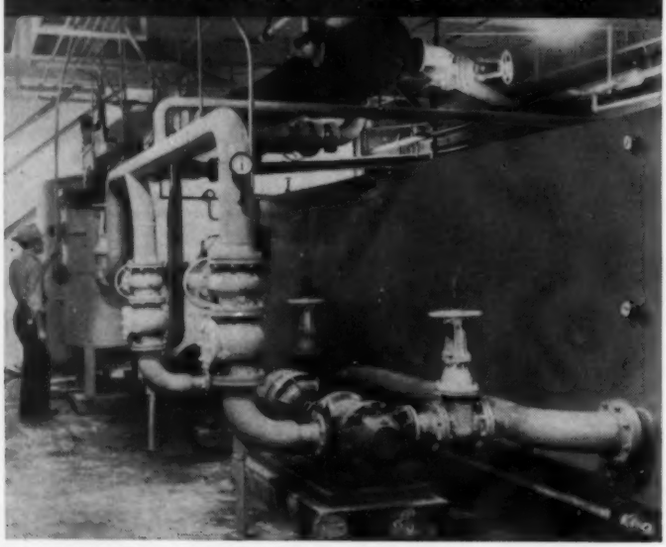

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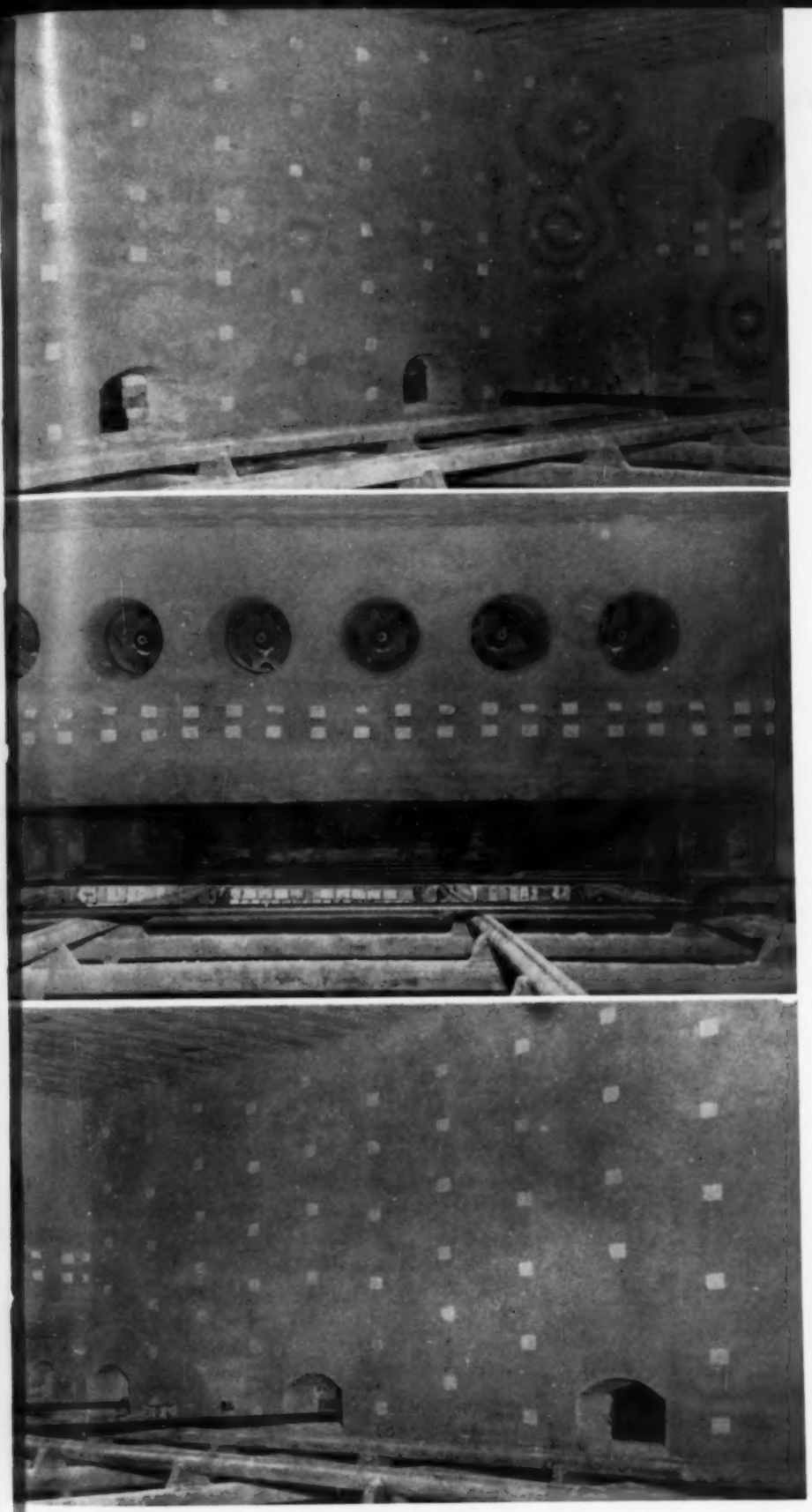

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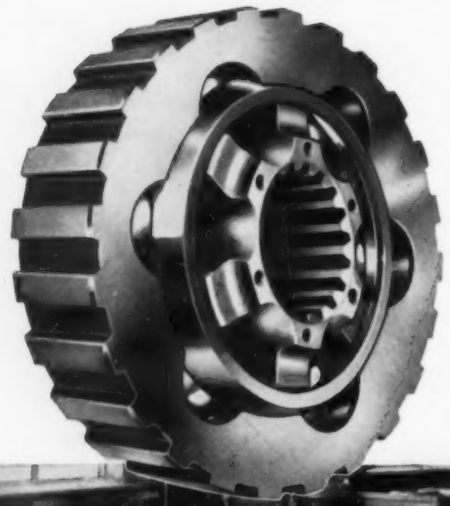

Only a universal joint specifically designed to transmit torques smoothly through unbalanced angles, will permit profitable operation of your mill at its maximum rated speed.

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You can actually *measure* these improvements Rzeppa Joints provide:

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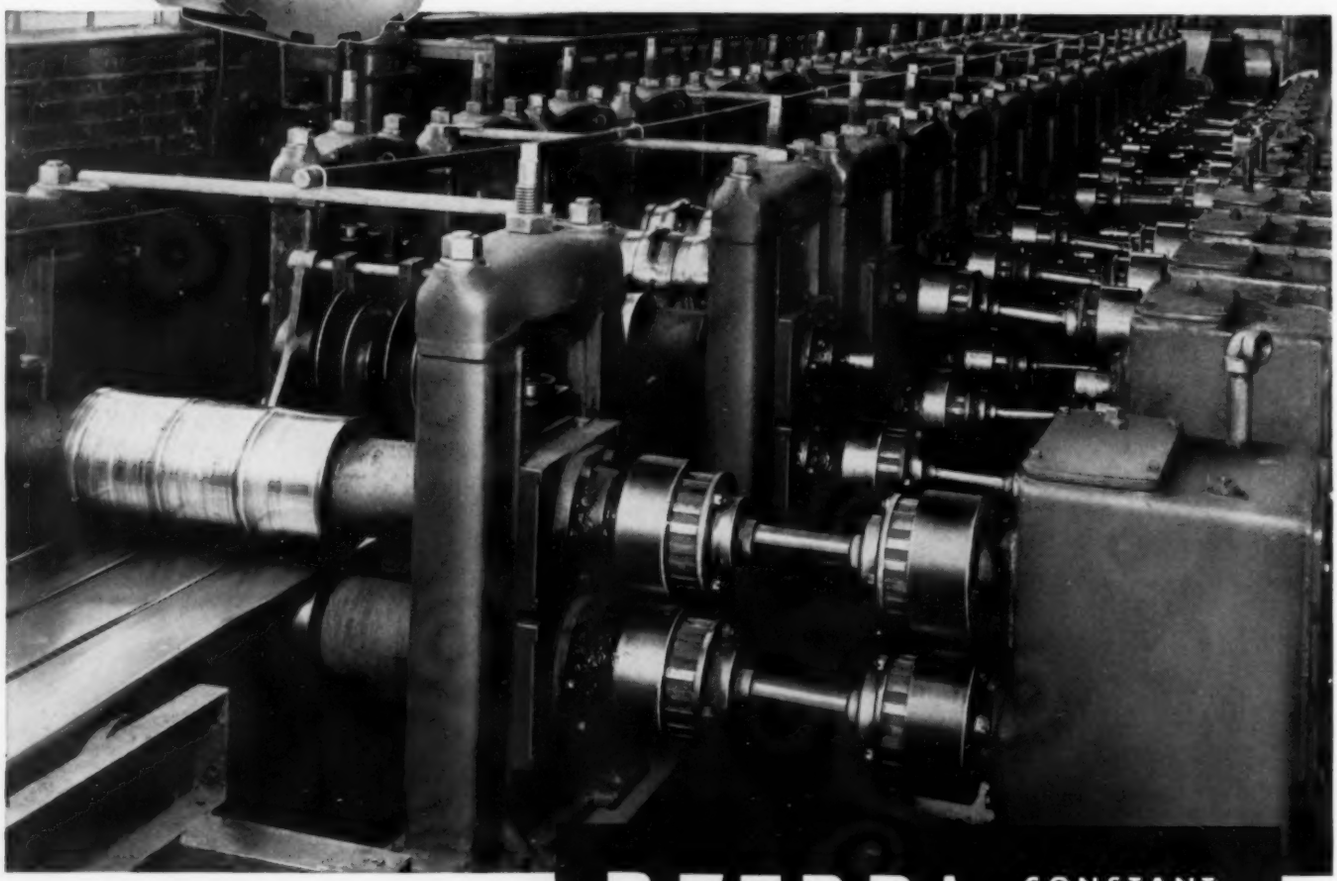

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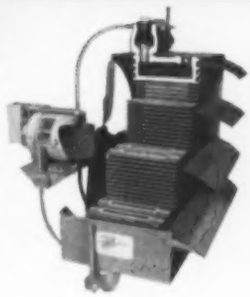

Corrosion in unit heaters — external, from contaminated air . . . internal, from electrolytic action *ENDS* — when your unit heaters are GRID cast iron construction, here's why — GRID heating sections are made of high-test cast iron . . . no external corrosion from acid or other fumes present in many plants.

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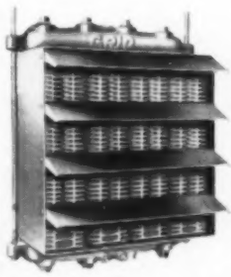
GRID construction ends your unit heater maintenance problems — because GRID will operate on steam pressures up to 250 P.S.I. . . . 450° temperature . . . no pressure-reducing valves needed. No soldered, brazed, welded or expanded connections . . . a specially designed threaded nipple provides a leak proof joint (see illustration).

GRID design gives you maximum heating performance because — GRID provides more air changes at lower outlet temperatures . . . carefully selected motor speeds and fan capacities positively deliver warm, comfortable air in ample volume to floor level . . . no wasted heat through stratification.



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BOOK REVIEWS

(*Continued from page 227*)

na. The book contains 216 pages, 6½ x 4 in., is cloth bound, and sells for $3.75.

"Oxygen in Iron and Steelmaking," by J. A. Charles, W. J. B. Chater, and J. L. Harrison, has recently been published by Butterworths Scientific Publications, 88 Kingsway, London, W.C. 2, England. The book contains 309 pages, 8½ x 5½ in., is cloth bound, and sells for 42s. The book deals in full detail with many applications of oxygen in iron-and steelmaking, critically reviews published information, and contains results obtained by many unreported trials, to get a clear and rapid assessment of oxygen applications. The subject matter is divided and discussed in three parts: treatment of the molten metal with oxygen, blast enrichment in solid fuel combustion, and flame enrichment. Ample illustrations, such as photographs, charts, tables, equations, and diagrammatic drawings, are used to supplement and explain the text.

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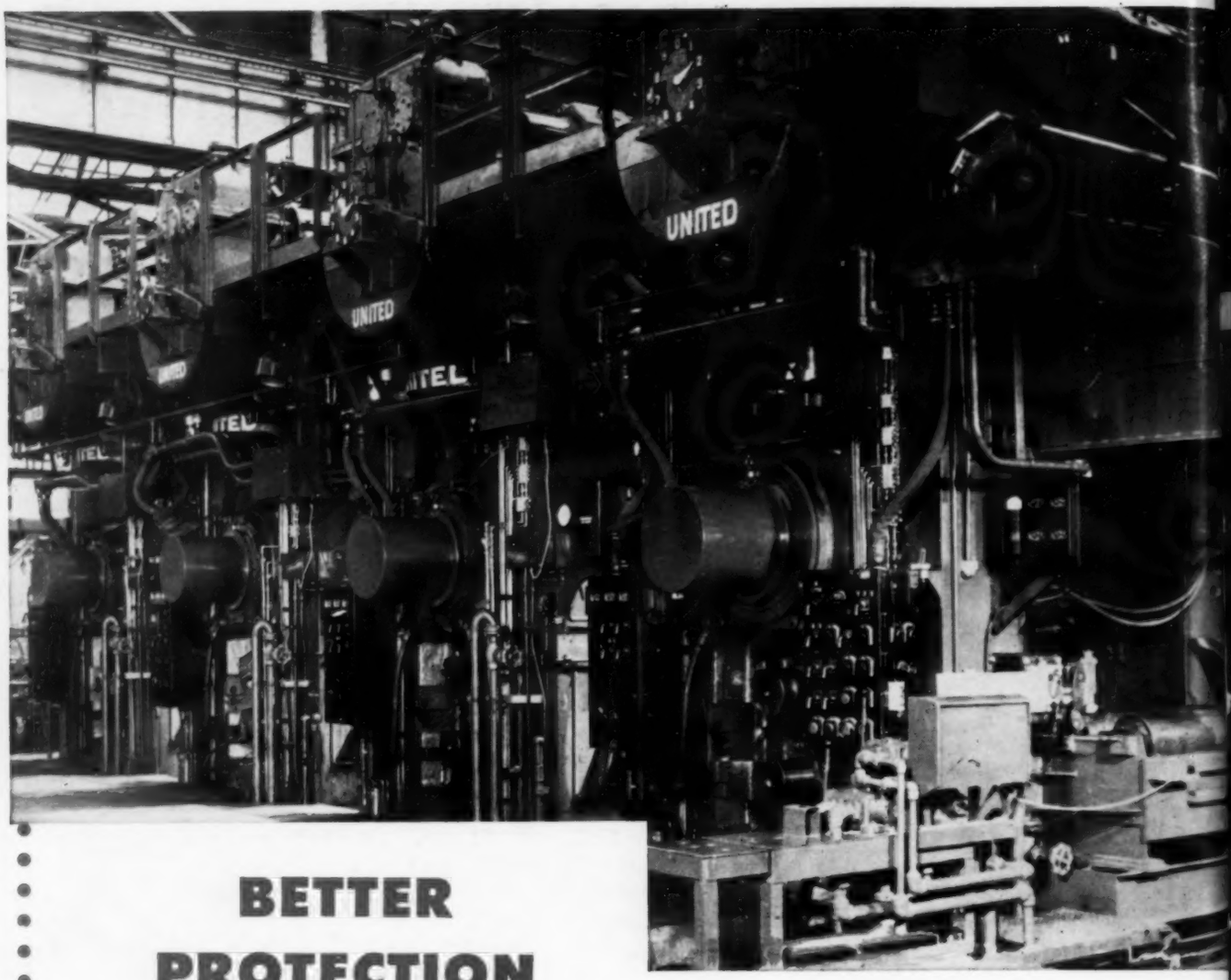

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